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ENGINEER-GEOLOGIST TEAM INVESTIGATES SUBSIDENCE

M. J. Shelton,[1] M. ASCE and L. B. James,[2] A. M. ASCE

SYNOPSIS

During the planning stages for California's Feather River Project aqueduct, it became apparent that large areas within the San Joaquin Valley were subject to two types of land subsidence which could seriously affect the operation and maintenance of a large conventional type canal. An engineer-geologist team was assigned the problem of studying the nature of this subsidence, delimiting susceptible areas and ultimately selecting the most favorable route, location and aqueduct design. This paper is primarily concerned with the methods which the team developed and utilized in delimiting scattered areas of potential subsiding lands aggregating over 2,000 square miles.

INTRODUCTION

To assist in the solution of water shortage problems, the State of California envisions a master aqueduct system entirely within the State which will convey water from areas of surplus supply to areas suffering from a deficiency. This project, known as The California Water Plan, would ultimately involve over 270 new reservoirs and many hundreds of miles of canal, pipe line and tunnels. The principal aqueducts of this Plan would convey surplus water from northern California to semi-arid southern California. The entire Plan would not be completed until early in the next century; however, at the present time, the State Legislature has authorized construction of the Feather River Project, the first phase of The California Water Plan, and has granted appropriations for continuing the study of the over-all Plan.

Fig. 1, a relief map of California, shows the principal geographical provinces of the State. The long, broad Central Valley of California, some

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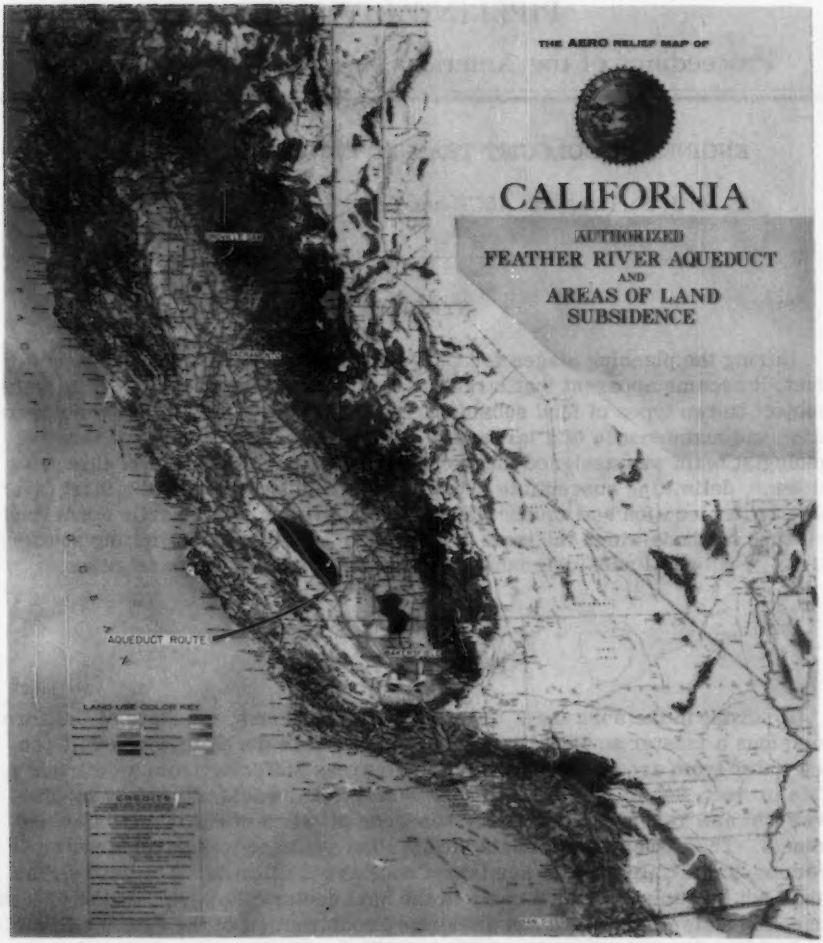


Relief map of California showing Feather River Project Aqueduct and areas of subsidence in San Joaquin Valley

Figure 1

500 miles in length, lies between the Coast Ranges and the Sierra Nevada Range. From the point of view of topography, the southern half of this valley, known as San Joaquin Valley, provides the best "country" for long aqueducts such as those contemplated in The California Water Plan. Shown is one of several possible alignments proposed for the Feather River Aqueduct, which would convey surplus waters from the proposed Oroville Reservoir on the Feather River through the San Joaquin Valley and into southern California as far south as San Diego.

The Subsidence Problem

There is a serious physical problem to be confronted in planning an aqueduct through San Joaquin Valley. This problem is one of land subsidence which is occurring at several places within the valley. The darkened areas on Fig. 1 indicate areas in which the land surface has settled or which are now known to be susceptible to subsidence.

The greatest subsidence in the San Joaquin Valley has occurred about 40 miles westerly of Fresno, as indicated by the northerly-most of the darkened areas. Here, lands devoted largely to the production of cotton, have settled as much as 20 feet, and the area, which has undergone subsidence of one foot or more, now is known to exceed 1,100 square miles. A very slight settlement was first noticed in this part of the valley as early as 1935. By 1953 a maximum of about seven feet had occurred, and as stated, it has now receded to a maximum depth of about 20 feet. Much of this subsidence has occurred since 1955.

To the southeast, in a second region, maximum subsidence now exceeds 13 feet, and the area subject to settlement of one foot or greater includes more than 500 square miles. The center of this second region lies near the towns of Delano and Earlimart.

A third region, smaller and less obvious, extends across the south end of the valley. Here, areas affected by subsidence are not yet clearly delimited and settlements have not been accurately measured.

In addition to the three regions shown, there are probably other parts of the valley as yet undeveloped which will subside when they first come under irrigation or when they are first traversed by canals or ditches.

San Joaquin Valley subsidence is of two distinct types, known respectively as "deep" and "shallow" subsidence.

"Deep" subsidence is attributed to prolonged pumping of deep water wells as a result of which artesian pressure heads have been lowered several hundred feet during the last 30 years. Decrease in pore pressures in the valley fill sediments has been accompanied by deep-seated consolidation resulting in surface settlement.

"Deep" subsidence is manifested by a gradual regional settlement, more or less evenly distributed. Large areas are depressed, but differential settlement is insignificant within these areas. As a consequence, the gradients of canals are altered, resulting in a reduction in their carrying capacities, but generally pipes and canal linings are left unharmed. "Deep" subsidence phenomena were the subject of a presentation before the ASCE Irrigation and Drainage Division at the National Convention in Portland, Oregon, on June 26, 1958, by J. F. Poland and G. H. Davis. Further discussion of the mechanics of this type of settlement has therefore been omitted from this paper.

The second type of subsidence known as "shallow" subsidence occurs when certain kinds of soil are saturated by irrigation waters or by canal seepage. From the standpoint of constructing and maintaining an aqueduct, shallow subsidence poses more serious problems. In contrast to "deep" subsidence, it is a rapid phenomenon which creates an uneven humocky topography. As a general sequence of events, canals or concrete pipes through regions susceptible to this kind of subsidence will develop cracks as a result of the slight, unavoidable leakage which occurs through the pores of all concrete linings. This leakage causes settlement which, in turn, creates further cracking and greater leakage. Thus, cracking and leakage progressively increase until the system is no longer operable.

Fig. 2 depicts typical subsidence cracks which have developed along an irrigation ditch about 40 miles west of Fresno as a result of seepage. The ditch channel on the left side of the photo was once only about three feet below the level of the land shown on the right of the photo; however, due to continued subsidence over a period of less than 10 years it now lies about 12 feet lower.

Figs. 3 and 4 show similar cracks near a sump utilized for disposal of the brines that accompany oil produced from the Maricopa Flat oil field near the southwest end of San Joaquin Valley. Cracks have been observed in this area

Typical subsidence cracks along an irrigation ditch.

Figure 2

with surface openings of several feet into which an uncautious observer could fall as far as 10 feet. County roads in this area are under continual repair and are prominently posted with signs stating that they are dangerous due to subterranean settlement.

Soils in San Joaquin Valley susceptible to "shallow" subsidence are generally associated with mudflows which occur in this region as a result of torrential downpours upon the barren slopes west and south of the valley. Where these slopes consist of loose sedimentary materials, mudflows consisting of a quasi-liquid mass of mud and pebbles are disgorged onto the valley floor. Upon drying, a highly porous deposit of low density remains which is highly susceptible to subsidence upon subsequent saturation.

The significance of the shallow type of subsidence from the standpoint of planning a major aqueduct is obvious. Since all concrete-lined canals leak to some extent, land subject to this kind of settlement must either be avoided by canals, or some measures to prevent its effects must be employed. Thus, the problem confronting the Department of Water Resources resolves into one of comparing alternatives, the cost of constructing canals routed to avoid areas of potential subsidence versus the cost of constructing and maintaining canals through such areas. Staff engineers and geologists are attacking the

A subsidence crack at Maricopa Flat southwest of Bakersfield, California.

Figure 3

problem as a team. They are being assisted by a consulting board comprising a civil engineer and an Engineering-Geologist.

Previous Investigation

Agencies in addition to the Department of Water Resources have, for some time, been interested in the scientific or practical aspects of San Joaquin Valley subsidence. These other agencies include the U. S. Geological Survey, the U. S. Coast and Geodetic Survey, the U. S. Bureau of Reclamation, the U. S. Army Corps of Engineers, University of California, Stanford University and the State Division of Highways.

Recognizing the fact that existing or proposed engineering structures, valued at many hundreds of millions of dollars, are or would be jeopardized by land subsidence, these public agencies organized an informal committee in 1955 to obtain fundamental physical data as required to evaluate the subsidence problem. This committee is known as the Inter-Agency Committee on Land Subsidence in the San Joaquin Valley. It is now functioning, and it has obtained much useful information.

Cracks near an abandoned sump for disposal of oil field brine, southwest of Bakersfield, California.

Figure 4

The investigations of the Department of Water Resources have been closely coordinated with activities of the Inter-Agency Committee.

The Investigation of Subsidence

Returning to problems directly associated with locating aqueduct routes, the engineer-geologist team has been primarily concerned with delimiting areas susceptible to settlement. Of the some 10,000 square miles comprising San Joaquin Valley, only about 2,000 square miles required investigation, the remainder being unsuited for a main line conduit for reasons other than subsidence.

Due to the urgency in selecting the most favorable aqueduct alignment, a " crash" program was undertaken by the "team". This program was designed to delimit subsidence areas rapidly and at reasonable cost. One hundred fifty thousand dollars were appropriated for this purpose.

A four-fold approach to the problem was adopted which included field canvassing, aerial reconnaissance, soils analysis and field experimentation.

Field Canvassing

The 2,000 critical square miles were covered by a rapid canvass, in which areas of possible settlement were inspected for subsidence manifestations and landowners were interviewed to collect information regarding any subsidence that their lands may have experienced in the past. Reservoirs, pipe lines and canals were inspected for indications of subsidence such as the cracks shown in Figs. 2 and 3. Evidence of mudflows, both recent and ancient, was sought and mapped.

Fig. 5 is a photograph of "armored mudballs", which are occasionally associated with mudflows. Viscous mud, during its flow from the slopes, gathers pebbles which form balls of mud and rocks which grow like snowballs as they roll downstream. These particular mudballs are almost two feet in diameter. They are called armored mudballs because their exteriors are plated with the pebbles accumulated during their travel.

Findings of the field canvass were tabulated and also plotted on a large scale map of the valley. This work was accomplished by four Engineering Geologists who also inspected tributary areas for evidence of mudflow potential and who mapped mudflow areas on the valley floor wherever these features could be recognized. About six months were spent in this phase of the program.

Aerial Reconnaissance

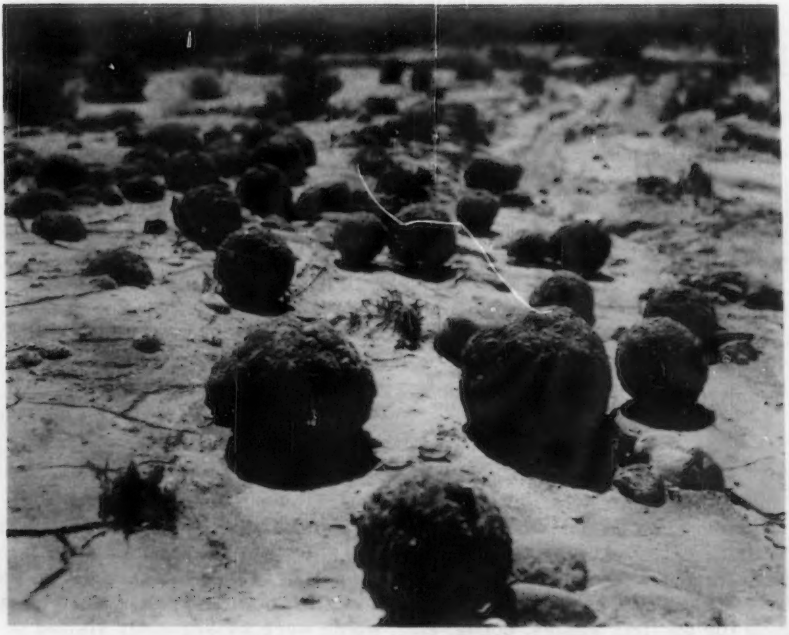
In undeveloped regions air search for mudflow deposits and other large scale indications of potential subsidence was undertaken. Recent flows were readily detected and mapped in this manner; however, the traces of ancient flows obscured by subsequent erosion, deposition or cultivation could not be discerned. Aerial reconnaissance also assisted in locating abandoned canals, sumps for oil field wastes, ponds, etc., which were subsequently visited by ground crews in their search for evidence.

Soil Analysis

The best single criteria diagnostic of potential shallow subsidence is probably soil density. Susceptible soils were found generally to range from 70 to 90 pounds per cubic-foot in dry density. In one instance, a sample which weighed less than 60 pounds per cubic-foot was obtained from a mudflow deposit.

Early in our studies it became apparent that conventional soil testing by itself would prove too costly a method of delimiting subsidence. This was largely because of the vast extent (2,000 square miles) of questionable land. This approach was therefore limited to checking critical areas which appeared suspicious for other reasons.

Search for a method more rapid and less expensive than conventional sampling and laboratory testing for soil density was undertaken. A nuclear probe was tried with varying success. This apparatus operates on the principle that moisture content and density of a soil are related to its ability to absorb and emit nuclear radiations. By lowering the proper radiation emiting and detecting devices into a precision drilled hole, data can be recorded theoretically by this device from which density and moisture content can be computed.



Armored mudballs in a mudflow, south end of San Joaquin Valley.

Figure 5

The team has been experimenting with a nuclear probe throughout the last year. Although the method shows promise, consistent reliable correlations are yet to be achieved. Inconsistencies to date are attributed in part to difficulty in calibrating the probe and to greater extent to the difficulty in obtaining a precision drilled hole to accommodate the instruments. Probe holes must be held to 1-1/2 inches in diameter. Furthermore, water cannot be utilized in the drilling process because its use would create an artificial settlement and alter the soil moisture content thereby invalidating the information sought. A method of drilling, which shows promise, utilizes a special bit and a compressed air jet by means of which it has been possible in some instances to drill 1-1/2 inch diameter holes to depths exceeding 100 feet.

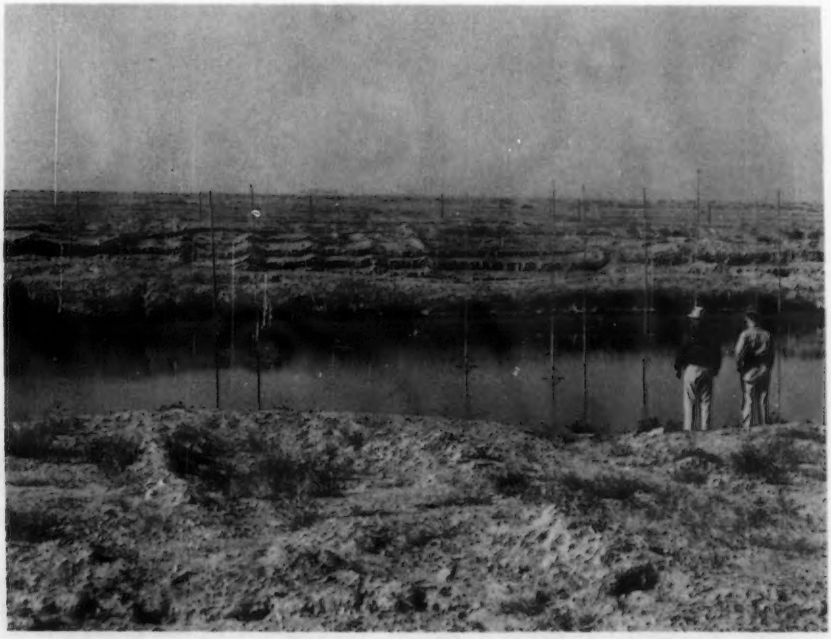
As these techniques improve, the nuclear probe is expected to become a valuable tool in the study of shallow subsidence problems. In addition to the lower cost of obtaining soil characteristics, the method offers one other especially inviting advantage in that it provides a means of periodically remeasuring densities and moistures of soils in situ. In studying the mechanics of "shallow" subsidence (that is, its relation to moisture content, seepage front and density changes) this instrument provides a method of periodically obtaining pertinent information from the original drill hole without disturbing the soils.

An experimental sump for observing artificially created subsidence.

Figure 6

Field Experimentation

As in most investigations, positive tests are desirable. For confirmation, where other approaches such as geologic mapping, interviews or soil tests indicate suspicious conditions to exist, final proof is the application of water and positive measurement of such subsidence as may result. Figs. 6 and 7 are photographs showing an experimental sump which was constructed by the Inter-Agency Committee on San Joaquin Valley subsidence. The water in this pond is maintained at about two feet deep. Although its surface now stands well below the level of the surrounding land, at the time of construction the base of the sump and the surrounding plain stood at approximately the same elevation. A settlement of about 10 feet has occurred since the pond was first filled in June, 1956. The subsidence cracks, which surround the plots, are apparent in the photographs. Settlement is measured by leveling to the staff gages which appear as eleven vertical rods barely discernable in the picture. Each of these eleven rods is attached to a bench mark, five being located on the floor of the sump and the other six being anchored at the bottom of drill holes at depth intervals ranging from 25 to 300 feet. All these bench marks, with the exception of the one at 300-foot depth, have now subsided, the shallower ones being most affected.



Subsidence cracks flanking an experimental sump.

Figure 7

Fig. 8 portrays curves which depict the subsidence recorded at the several subsurface bench marks at test plot B. Note that the surface bench marks subsided in the order of their depths. Note that subsidence of the 150-foot bench mark did not occur until after almost 16 months saturation. The consensus of team engineers and geologists is that the 300-foot bench will not recede before 100 years.

Fig. 9 depicts curves of the Inter-Agency Committee showing the compaction that has occurred at test plot B within successive intervals between subsurface bench marks and also the infiltration rates that were observed at the pond. After application of water early in October, 1956, the 0- to 25-foot interval was first to compact followed by the 25- to 50-foot interval, 50- to 75-foot, 75- to 100-foot and finally after nearly sixteen months, the interval below 150-foot depth. In each of the shallower zones, compaction was followed by a slight expansion as indicated by the gradual upward slope of the curves. This expansion is probably due to the presence of swelling clay minerals such as montmorillonite. It will be noted that as the depth of the compacted interval increased the compaction also increased. This reflects the effect of added overburden load.

The Department of Water Resources has installed seven less expensive ponds of much smaller dimensions. As shown on Figs. 10, 11, 12 and 13,

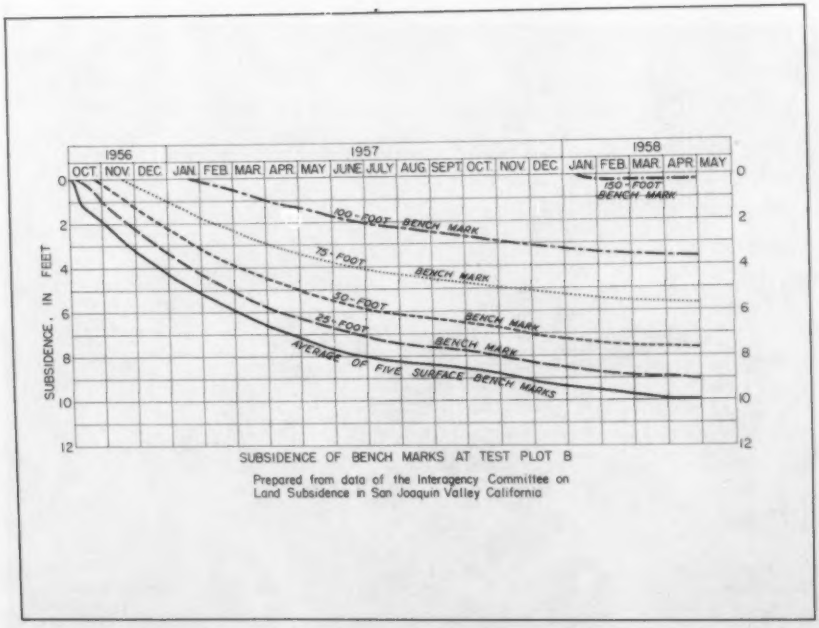


Figure 8

these consist of six-foot lengths of eight-foot diameter culvert pipe. Constant head within these miniature plots is assured by means of a float valve on the supply line. (Figs. 10 and 13). Water is supplied from collapsible tanks which are periodically filled from a tank truck. The vertical staffs are graduated level-rods fastened to 1/2-inch pipes which are, in turn, attached to concrete bench marks located in drilled holes at depths of 25, 50 and 100 feet. Concentric rings of subsidence cracks are apparent in the photographs. This particular plot, near Maricopa, had been in operation about three months at the time of this picture and the surface had settled about 3-1/2 feet. As of September 26, 1956, the surface of this plot had sunk 5.71 feet and the bench mark at 25 feet below the surface had settled 3.77 feet.

In an attempt to establish an inexpensive, positive test for detecting potential shallow subsidence, several other types of experimental sump were tried. These ranged from small pits of various shapes and sizes to bottomless 50-gallon drums. Most of these proved unsuccessful, apparently because "bridging action" in the sediments prevented or impeded settlement in small plots. Figs. 14 and 15 show a method which appears promising. Shown is a gravel-packed well 25 feet in depth consisting of a 10-inch diameter perforated casing surrounded by a 20-inch envelope of loose gravel. Water injected

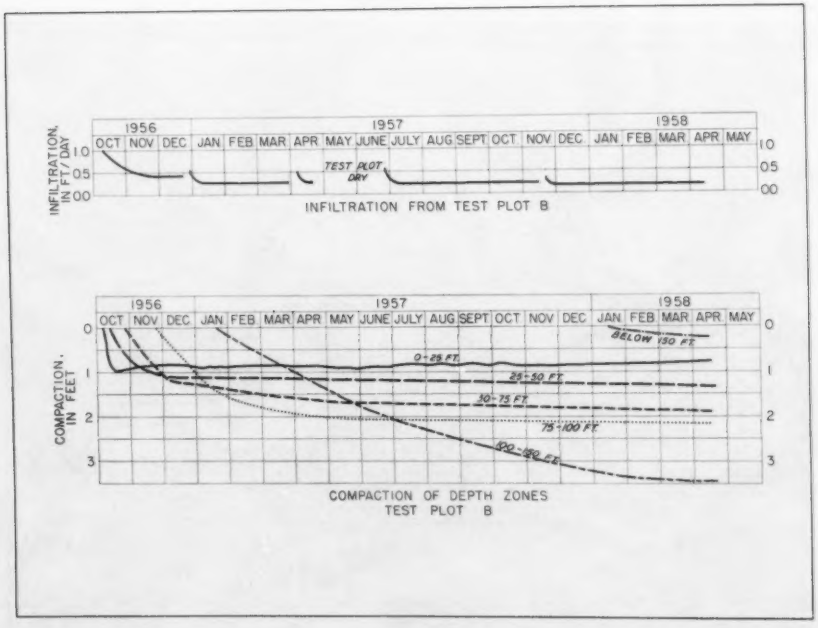


Figure 9

in the central casing has caused the concentric cracks and sinking so apparent in these pictures. Wells such as these provide a positive test which is more rapid and less expensive than either the large earthern plots or the culvert pipe plots.

Studies in Progress

As previously stated, the investigation comprises two parts, delimitation of areas susceptible to subsidence and experimentation with construction methods. This presentation has been limited to the first, that of delimiting areas of existing and potential land subsidence. The second part of the investigation, now in progress, involves construction and operation of large scale experimental plots which will be utilized to obtain knowledge pertinent to the best methods of constructing conduit across potential subsiding lands. Emphasis is being placed on determining the most effective means of preconsolidating susceptible soils to the extent that conduits subsequently constructed across them would not sustain appreciable damage. The program has as its primary purpose the investigation of various methods of preconsolidation with secondary interest on experimental types of water-tight canal linings.

A miniature experimental subsidence sump.

Figure 10

Measuring subsidence effects at a miniature sump.
Figure 11

Questions to be answered during this stage of investigation include the following:

1. What type of application of water is the most effective for use in pre-consolidation along the canal alignment?
2. How much and how long must water be applied to accomplish desired results?
3. Are there mechanical methods such as pressure grouting or vibrations that can be used effectively?
4. Will the injection of water at depth materially increase the degree and rate of subsidence?
5. Which would be the best canal sections and type of lining to use in subsidence areas?

CONCLUSION

As a conclusion to this paper, we of the Department of Water Resources recognize land subsidence as a serious, but by no means insurmountable problem, to be confronted in constructing the Feather River Project and other

Miniature subsidence sump showing plastic film cover to reduce evaporation loss.

Figure 12

subsequent aqueducts proposed in The California Water Plan. The problem is unique and therefore has demanded intensive research. As a result of this research, we feel that the limits of lands susceptible to serious "shallow" subsidence are now reasonably established. Also, we have gained knowledge relative to the problem of estimating subsidence rates and depths of settlement to be expected in San Joaquin Valley, California. The integrated geologist-engineer team approach to this problem is a typical example of the method that has been adopted by the California State Department of Water Resources for investigating foundations, dam sites, tunnels and other similar engineering problems.

Details of miniature subsidence sump showing float actuated valve.

Figure 13

Subsidence in vicinity of an experimental injection well.

Figure 14

Concentric cracks surrounding an experimental injection well.

Figure 15

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FEDERAL-AID HIGHWAYS AND PUBLIC UTILITIES[a]

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ABSTRACT

Federal legislation controlling participation with Federal-aid highway funds in costs of adjustments in public utility installations made necessary by highway developments is cited. Administration of that legislation by the Bureau of Public Roads with the State highway departments and utilities and the principles of the Bureau's Policy and Procedure Memorandum 30-4 are discussed.

The Nation's public highways and public utilities are developed, operated, and maintained by many separate and distinct governmental agencies, individuals, private corporations and governmental corporations acting in a private capacity under direct or implied governmental grants of power. Both highways and utilities are provided to serve certain common wants of the public. To fulfill these wants in an orderly manner and with an overall optimum benefit, the several agencies must maintain close liaison and each should have a good understanding of the requirements and the responsibilities of the others with which it deals.

The Bureau of Public Roads of the U. S. Department of Commerce is responsible for administration of the Federal-aid highway funds authorized under the Federal-Aid Highway Acts. To provide other affected parties with a better understanding of the reasons for the requirements set forth in the Bureau's Policy and Procedure Memorandum No. 30-4, "Reimbursement for Utility Work," certain provisions of the Federal legislation pertinent to the matter of participation of Federal-aid highway funds in the costs of

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a. Presented at the October 1958 ASCE Convention in New York, N. Y.

1. Asst. Commissioner for Eng., Bureau of Public Roads, Washington, D. C.

adjustments in public utility installations made necessary by highway developments are hereafter reviewed.

As a beginning, there was approved on July 11, 1916, an Act to provide that the United States shall aid the States in the construction of rural post roads. That Act and its first two amendments approved February 28, 1919, and November 9, 1921, contained, among others, the following definitions:

> Highway includes rights-of-way, bridges, drainage structures, signs, guardrails and protective structures in connection with highways, but shall not include any highway or street in a municipality having a population of 2,500 or more as shown by the latest available census, except that portion of any such highway or street along which within a distance of one mile, the houses average more than 200 feet apart.
>
> Construction means the supervising, inspecting, actual building, and all expenses incidental to the construction of a highway, except locating, surveying, mapping and costs of rights-of-way.

The 1921 amendment provided that any State having complied with the provisions thereof, and desiring to avail itself of the benefits thereof, shall by its State highway department, submit to the Secretary project statements setting forth proposed construction or reconstruction of any highway therein which has been designated a part of the Federal-aid system of highways. Further, if the Secretary approves the project, the State highway department shall furnish him such surveys, plans, specifications and estimates therefor as he may require, and if the said surveys and P.S. and E. are approved by the Secretary, the work shall be undertaken by the State highway department and done under its direct supervision subject to the inspection and approval of the Secretary and in accordance with the rules and regulations issued by him pursuant to the Federal Highway Act and subsequent amendments.

While there have been numerous amendments and supplemental Acts since 1921, there are several cardinal principles of the initial Acts which have not been changed. They warrant emphasis for they are basic to all Federal-aid highway undertakings. They are in brief—

It is a Federal-aid program.

It is aid to improve a limited mileage of highways jointly selected by the State highway departments and the Federal Government.

The aid is restricted to the construction, reconstruction, and improvement of highways designated as parts of a Federal-aid system of highways.

It is a cooperative program in which all projects involving Federal-aid reimbursement are to be proposed by the State highway departments. All proposed projects must be approved by the Federal Government before there can be a commitment of Federal-aid funds, and, except for certain projects in those States operating under the 1954 Secondary Road Plan, the work under an approved project must also be approved before the State highway department may proceed with the undertaking if it is later to claim reimbursement of the Federal share of the costs.

During the years 1916 through 1944, the use of Federal-aid highway funds was limited, with few exceptions, to participation in the costs of the actual building of those portions of the one Federal-aid highway system then designated that were outside those places having a population of 2,500 or more. The exceptions were under the National Industrial Recovery Act (June 16, 1933), the Emergency Relief Appropriation Act of 1935, and the Defense

Highway Act of 1941, which Acts permitted the use of Federal-aid funds for surveys and plans, for rights-of-way, and for construction of highways within urban areas.

There has always been and will be Federal interest in the surveys and the studies of locations of highways and in the rights-of-way acquired for the locations adopted, for these items have an important bearing on the design, the suitability and the cost of the highway project. However, under the regular Federal-Aid Highway Acts, until that of 1944, there could not be Federal-aid participation in the costs for preliminary engineering or for rights-of-way. Since most of the construction was in rural areas, and generally had little or no effect on existing utility installations, there was little cost involved in utility adjustments. In many instances the States were not required to make payments for adjustments of utilities that were accommodated on the highway rights-of-way. Whenever a State was required to pay for utility adjustments it frequently elected not to request Federal-aid participation in such costs. If it did elect to request Federal-aid participation, the Bureau of Public Roads accepted such requests and made reimbursement for eligible portions of the construction work under an administrative interpretation of the cited definitions of "highway" and "construction" which regarded the cost of utility adjustment as a part of the cost of highway construction.

The Federal-Aid Highway Act of 1944, approved December 20, 1944, made sizeable increase in the amounts of Federal-aid funds to be apportioned to the States. The Congress, for a number of sound reasons, also saw fit to modify the definition of "Construction" to provide that the term would include "locating, surveying, and mapping, costs of rights-of-way, and elimination of hazards of railway-grade crossings." The Act authorized continuance of a Federal-aid primary highway system, the establishment of a Federal-aid secondary highway system, the establishment of a National System of Interstate Highways to be a portion of the primary system, and authorized extensions of these three systems within urban areas. The Act provided three classes of funds for primary, secondary, and urban projects. Thus, in late 1944, the scope of the use of Federal-aid funds was broadened to include preliminary engineering, rights-of-way, and the construction of highways within urban areas.

The Federal-Aid Highway Act of 1956 coupled with the Highway Revenue Act of 1956, approved June 29, 1956, continued the authorizations for projects on the primary and secondary highway systems and their extensions within urban areas in sizeable amounts, and authorized a total of $ 24.825 billion for the fiscal years 1957 through 1969 to expedite the construction of the Interstate System.

Section 111 of the 1956 Act, while not amending the term "Construction," provides a statutory basis for Federal-aid reimbursement to the States of a part of the cost of relocating utility facilities necessitated by highway improvement. Section 111, as amended by the Federal-Aid Highway Act of 1958, is quoted in full hereafter.

"SEC. 111. RELOCATION OF UTILITY FACILITIES.

"(a) Availability of Federal Funds for Reimbursement to States.—Subject to the conditions contained in this section, whenever a State shall pay for the cost of relocation of utility facilities necessitated by the construction of a project on the Federal-aid primary or secondary systems or on the Interstate System including extensions thereof within

urban areas, Federal funds may be used to reimburse the State for such cost in the same proportion as Federal funds are expended on the project: PROVIDED, That Federal funds shall not be reimbursed to any State under this section when the payment to the utility violates the law of the State or violates a legal contract between the utility and the State: PROVIDED FURTHER, that such reimbursement shall be made only after evidence satisfactory to the Secretary shall have been presented to him substantiating the fact that the State has paid such cost from its own funds with respect to Federal-aid highway projects for which Federal funds are obligated subsequent to the date of enactment of the Federal-Aid Highway Act of 1958 for work, including relocation of utility facilities."

"(b) Utility Defined.—For the Purposes of this section, the term "utility" shall include publicly, privately, and cooperatively owned utilities.

"(c) Cost of Relocation Defined.—For the purposes of this section, the term "cost of relocation" shall include the entire amount paid by such utility properly attributable to such relocation after deducting therefrom any increase in the value of the new facility and any salvaged value derived from the old facility."

Partly because of the need of many States to use all available State funds to match presently authorized Federal-aid funds, and partly because of the provision in the 1956 Act that Interstate System funds for fiscal years 1960 through 1969 would be apportioned on the basis of factors which are the ratios of the cost of completing the Interstate System in each State to the cost of completing the System in all of the States, it has become a practical necessity for all State highway departments to include under the Federal-aid highway program for the Interstate System all work of preliminary engineering, rights-of-way and construction, including all eligible work of utility adjustments associated therewith. In addition, many States are finding it necessary to similarly request Federal-aid participation on all phases of work financed with funds apportioned for projects on the primary and secondary systems and on their extensions in urban areas.

In recognition of these conditions the Bureau of Public Roads reviewed its operating procedures, both those required by terms of the Federal-Aid Highway Acts, and those established administratively pursuant to such Acts. There has been extensive and continuing liaison with the cooperating parties and consideration of their suggestions. Policy and Procedure Memorandum 30-4, Payment Procedures for Reimbursement for Utility Work, issued December 31, 1957, is one of a number of such memorandums that has been so developed.

Essentially, three basic legal principles are involved in PPM 30-4. First, just compensation will be paid where there is a taking of property. This principle is reflected in the provisions of paragraph 3a(1) which authorizes Federal reimbursement where the utility has a right of occupancy in its existing location by reason of holding the fee or an easement, or other property interest. A utility which is required by necessities of highway construction to give up such a real property right is being deprived of its property, and due process of law requires payment of just compensation for the taking. PPM 30-4 accordingly provides for Federal reimbursement of a portion of the costs incurred under such circumstances.

The second principle is that Federal funds may participate where the State pays for utility relocation and such payment does not violate either State law or any legal contract between the utility and the State. This principle, which is expressed in paragraph 3(a)(2), is a restatement of the requirements of Section 111 of the Federal-Aid Highway Act of 1956, and because the statute establishes these conditions as prerequisites for Federal reimbursement, the PPM requires the States to certify the existence of the required facts.

The third legal principle is one which is inherent in the administration of any statute, namely, that the administering agency has the authority, and the duty, to carry out its statutory responsibilities in a manner reasonably adapted to accomplish the purposes of the statute. This is the principle which, on the one hand, authorizes the administering agency to take measures reasonably adapted to carry out the objectives of the legislation and, on the other hand, imposes the responsibility on the agency to protect the Government's interest. This is the legal principle which underlies the administrative requirements in PPM 30-4 that are designed to assure that Federal funds will be devoted only to the intended and authorized purposes.

Another legal requirement expressed in the PPM warrants explanation. Paragraph 1(c) of the PPM provides, in substance, that where agreement and payment standards authorized under State law vary from those in PPM 30-4, the more restrictive standards shall govern. Essentially, this is a matter of statutory requirement and is the result necessitated by applying the provisions of subsections (a) and (c) of Section 111 of the 1956 Act. Subsection (c) defines cost of relocation as including the entire amount paid by such utility properly attributable to such relocation. Since Federal reimbursement is authorized for relocation costs as so defined, the effect of subsection (c) is to require ascertaining how much of the amount paid by the utility is properly attributable to the relocation. This is the payment standard authorized in the PPM. The agreement and payment standards authorized by the PPM are the maximum permitted by the statute. Consequently, if the State utility agreement and payment standards are more liberal than those authorized by the PPM, the Federal Government must reimburse on the more restrictive basis of the PPM because it cannot exceed its own authority under Section 111(c). If, on the other hand, State reimbursement is more restrictive than that authorized by the PPM, then the Federal Government, in exercising its authority, is limited by the amount actually paid by the State, because Section 111(a) limits Federal reimbursement to the basis of the amount actually paid by the State.

The administrative provisions of the PPM under Definitions, Rights-of-Way, Preliminary Engineering, and Construction are not different from provisions that apply to Federal-aid highway projects not involving utility adjustment.

The provisions under Agreements and Authorizations are pertinent only to projects involving utility adjustments. The objectives of these provisions are to assure that there is complete understanding between the Bureau of Public Roads and a State highway department as well as between the State and any affected utility as to the extent of the work under separate phases, as to the plans, specifications and estimates therefor, the manner of construction and the bases of payments before the Bureau gives approval thereto and authorizes that the work may proceed. With these understandings, approvals and authorizations, all parties are protected in so far as the use of and the reimbursement from Federal-aid highway funds is concerned.

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In recognition of these conditions the Bureau of Public Roads reviewed its operating procedures, both those required by terms of the Federal-Aid Highway Acts, and those established administratively pursuant to such Acts. There has been extensive and continuing liaison with the cooperating parties and consideration of their suggestions. Policy and Procedure Memorandum 30-4, Payment Procedures for Reimbursement for Utility Work, issued December 31, 1957, is one of a number of such memorandums that has been so developed.

Essentially, three basic legal principles are involved in PPM 30-4. First, just compensation will be paid where there is a taking of property. This principle is reflected in the provisions of paragraph 3a(1) which authorizes Federal reimbursement where the utility has a right of occupancy in its existing location by reason of holding the fee or an easement, or other property interest. A utility which is required by necessities of highway construction to give up such a real property right is being deprived of its property, and due process of law requires payment of just compensation for the taking. PPM 30-4 accordingly provides for Federal reimbursement of a portion of the costs incurred under such circumstances.

The second principle is that Federal funds may participate where the State pays for utility relocation and such payment does not violate either State law or any legal contract between the utility and the State. This principle, which is expressed in paragraph 3(a)(2), is a restatement of the requirements of Section 111 of the Federal-Aid Highway Act of 1956, and because the statute establishes these conditions as prerequisites for Federal reimbursement, the PPM requires the States to certify the existence of the required facts.

The third legal principle is one which is inherent in the administration of any statute, namely, that the administering agency has the authority, and the duty, to carry out its statutory responsibilities in a manner reasonably adapted to accomplish the purposes of the statute. This is the principle which, on the one hand, authorizes the administering agency to take measures reasonably adapted to carry out the objectives of the legislation and, on the other hand, imposes the responsibility on the agency to protect the Government's interest. This is the legal principle which underlies the administrative requirements in PPM 30-4 that are designed to assure that Federal funds will be devoted only to the intended and authorized purposes.

Another legal requirement expressed in the PPM warrants explanation. Paragraph 1(c) of the PPM provides, in substance, that where agreement and payment standards authorized under State law vary from those in PPM 30-4, the more restrictive standards shall govern. Essentially, this is a matter of statutory requirement and is the result necessitated by applying the provisions of subsections (a) and (c) of Section 111 of the 1956 Act. Subsection (c) defines cost of relocation as including the entire amount paid by such utility properly attributable to such relocation. Since Federal reimbursement is authorized for relocation costs as so defined, the effect of subsection (c) is to require ascertaining how much of the amount paid by the utility is properly attributable to the relocation. This is the payment standard authorized in the PPM. The agreement and payment standards authorized by the PPM are the maximum permitted by the statute. Consequently, if the State utility agreement and payment standards are more liberal than those authorized by the PPM, the Federal Government must reimburse on the more restrictive basis of the PPM because it cannot exceed its own authority under Section 111(c). If, on the other hand, State reimbursement is more restrictive than that authorized by the PPM, then the Federal Government, in exercising its authority, is limited by the amount actually paid by the State, because Section 111(a) limits Federal reimbursement to the basis of the amount actually paid by the State.

The administrative provisions of the PPM under Definitions, Rights-of-Way, Preliminary Engineering, and Construction are not different from provisions that apply to Federal-aid highway projects not involving utility adjustment.

The provisions under Agreements and Authorizations are pertinent only to projects involving utility adjustments. The objectives of these provisions are to assure that there is complete understanding between the Bureau of Public Roads and a State highway department as well as between the State and any affected utility as to the extent of the work under separate phases, as to the plans, specifications and estimates therefor, the manner of construction and the bases of payments before the Bureau gives approval thereto and authorizes that the work may proceed. With these understandings, approvals and authorizations, all parties are protected in so far as the use of and the reimbursement from Federal-aid highway funds is concerned.

The remaining provisions under Recording of Costs, Reimbursement Basis, Labor, Materials and Supplies, Equipment, Transportation, and Utility Bills are statements of standard practices of cost accounting that have been established through experience and found satisfactory for both payment and reimbursement purposes. A manner of recording of costs that is in accordance with the system of accounts prescribed for the utility company by a State or a Federal regulatory body is also proper for Federal-aid highway work.

A primary responsibility assigned the Bureau of Public Roads is to limit the usage of Federal-aid highway funds to highway construction. With regard to utility adjustments, Federal-aid funds cannot be expended for work that increases the capital value of the physical plant or operating facilities of a utility, nor to pay for any of its normal operating costs. For this reason it is not possible for the Bureau to accept several suggestions which would appear to simplify administration.

For illustration, the suggestion has been made that settlement of utility relocation costs should be determined by negotiation between the State and the utility, and that Federal reimbursement should be made on the basis of the negotiated amount rather than on the basis prescribed in PPM 30-4. Section 111(c) of the 1956 Act requires that reimbursement be limited to the amount actually paid by the utility that is properly attributable to the relocation. If such a negotiated amount was not properly attributable to the relocation, a portion of that amount would be outside the scope of the authorized Federal reimbursement.

It has also been suggested that the amount of utility relocation costs should be determined by application of the law of valuation in eminent domain in the same manner as acquisition of rights-of-way. Such a procedure would ignore a basic distinction between acquisition of right-of-way and utility relocation. It may be said there is a "taking of property" in connection with utility relocation, but the essence of such a relocation is not so much the deprivation or taking away of a property right, as the substitution of one geographic situs for another as the place where the right may be exercised. In that respect, reimbursement for utility relocation costs is analogous to the allowance of severance damages. Where property is taken, there is a measure of just compensation in terms of the market value of the property taken and the depreciation in the market value of the owner's remaining real property resulting from the taking. Small segments of utility facilities are not ordinarily bought and sold in the open market, and the value of the taking and damaging resulting from a utility relocation project is not readily ascertainable by a market value approach. In the relocation of utility facilities, the right to maintain the facility is not taken. After relocation the utility exercises that right at a different location. The measure of just compensation is the cost actually incurred in effecting the change that is necessitated by the highway improvement. If the utility is reimbursed for such cost, its financial and productive situation is the same as if the relocation had not occurred.

While the objective of restoring the utility to its former status is not complicated, the details of carrying it out became involved because of complicated factual situations. Where, for example, the utility relocation involves merely the picking up from one location and setting down in another the identical physical property, the cost of relocation consists of the labor, engineering and other incidental necessary expenses including in some cases rights-of-way. On the other hand, where, as part of the relocation, the utility constructs

new, additional, or improved facilities at the new location, it is necessary to determine how much of the expense incurred is properly attributable to the relocation necessitated by the highway improvement. In such cases it becomes necessary to determine the extended life of the new facility, over that of the old, and the salvage value of the old facility; for if credit for these items is not obtained, the utility's position will be enhanced rather than restored.

As another illustration consider the accounting, first, for a relocation accomplished without replacement of the existing materials, except for relatively minor items; and second, for a relocation accomplished through placement of new materials with recovery or abandonment of the existing materials.

Under the first method, the utility company accumulates all costs, both direct and indirect, incurred and chargeable to the relocation work, in work order accounts provided by most of the prescribed or approved systems of accounts. This is a relatively simple operation which provides the State and Public Roads a simple and uniformly maintained source of reference to company documents and records giving proof of amounts paid on account of the relocation. Since the utility facility remains unchanged except for its location there appears here no question of increase in value or major salvage credit. Reimbursement under this method merely returns to the company the amounts paid and there is no effect on the company's primary plant accounts.

Under the second method, the work order accumulation of direct and indirect costs and credits for recovered materials is done in the same manner as under the first. However, due to the replacement of the physical facility itself the amounts reported as paid do not necessarily represent amounts reimbursable under the governing Act. There must first be a determination with respect to increase in value of the new facility and salvage value derived from the old facility. The policy adopted by Public Roads on this point is expressed in paragraph 7(f) of PPM 30-4. This policy is premised on the concept that the use of new materials does not alone create an increase in the value of a utility facility. Rather, the new materials are viewed as a component of the facility and an increase in value recognized only where this component can be expected to remain in useful service beyond the time of replacement of the facility as a whole. In other words, an anticipated extension in service life is a condition precedent to a finding of increase in value. Where the finding here is affirmative, compliance with the Federal Act as it pertains to increase in value and to salvage value is gained through application of the factor, determined as the percentage of depreciation of the old facility, to the net replacement cost of the new facility; net replacement cost being the costs and credits accumulated in the work order accounts, exclusive of the cost of removal of the old facility and any temporary construction charges. The net result is a charge to the highway user for the amounts paid by the utility company for the replacement itself and a charge to the utility consumer for the cost the company has incurred in providing the added period of useful service life of the facility.

It is difficult for an operating agency to adjust its own procedures to that of another. On the other hand, an agency that operates with a large number of other agencies on a matter common to all must establish uniform procedures. This is what the Bureau has done, and it is of the opinion that the procedures will be found satisfactory by the 52 highway departments as well as by the great number of utilities with which it cooperates. If changes are proposed, they will first be tested for conformity with the law, and if satisfactory on that

score, will then be tested as to acceptability for nationwide usage and as to reducing the processing and recording and auditing workloads. The Bureau will welcome any constructive suggestions that may be developed by the utilities and by those who are directly engaged in the task of translating the Federal-aid funds into physical improvement of the highways of this Nation.

Journal of the

PIPELINE DIVISION

Proceedings of the American Society of Civil Engineers

REGULATION OF PIPELINE DESIGN AND CONSTRUCTION

Progress Report of the Task Committee on Investigation of Problems Involved in Regulation of Pipeline Design and Construction by Various Governmental Agencies of the Committee on Pipeline Design, Specifications and Operating Standards of the Pipeline Division

ABSTRACT

Pipeline design and construction is regulated in varying degree by Federal agencies, State bodies, and other minor governmental subdivisions. Applicable codes, administrative orders, and other rules and regulations have been compiled and briefly abstracted to indicate their scope. Although presented as a complete compilation, the probable existence of additional pertinent regulations is recognized.

The Committee on Pipeline Design, Specifications and Operating Standards of the Pipeline Division, Carter L. Shea, Chairman, on September 26, 1957 in St. Louis, Missouri, established a "Task Committee on Investigation of Problems Involved in Regulation of Pipeline Design and Construction by Various Governmental Agencies."

The Task Committee has solicited, assembled, reviewed and abstracted all codes, rules and regulations governing the design and construction of pipelines insofar as they have been able to determine the existence of such regulations.

The Interim Report is submitted solely as a compilation without comment or opinion. There may be errors or omissions which were not revealed through the advance circulation of the drafts. Corrections, additions, comments and discussion are solicited and desired.

Pipeline design and construction is controlled and regulated in varying degree by Federal agencies, State bodies, and by minor governmental subdivisions:

Note: Discussion open until October 1, 1959. To extend the closing date one month, a written request must be filed with the Executive Secretary, ASCE. Paper 2025 is part of the copyrighted Journal of the Pipeline Division, Proceedings of the American Society of Civil Engineers, Vol. 85, No. PL 2, May, 1959.

A. Federal Agencies:

Federal regulations which affect the design or construction of pipelines are incidental to administrative regulation or the granting of permits and rights-of-way; e.g.—

(1) The Federal Power Commission, under the Natural Gas Act of 1938, prior to issuance of Certificates of Public Convenience and Necessity must determine that the applicant is able, by means of the planned facilities, to properly perform the services proposed. The Interstate Commerce Commission, to a lesser extent, exercises limited control of common carrier oil and product pipelines.

(2) Corps of Engineers (by the District Engineer in each case) issue permits for pipeline crossings of navigable streams under the provisions of Section 10, Act of Congress approved March 3, 1899. The only restrictions on design and construction are those pertaining to navigation, such as depth below mean low water, method of dredging and disposal of dredged materials.

(3) Tennessee Valley Authority acts in a capacity similar to the Corps of Engineers in granting permits for crossings of the Tennessee River and its tributaries.

(4) Bureau of Land Management, Department of the Interior issues permits for rights-of-way over public lands, including forest reserves (under 41 Stat. 437; 30 U.S.C. 22, 48, 181), and the Bureau of Indian Affairs issues permits for rights-of-way over Indian lands. No conditions affecting design or construction connected to these permits have come to our attention.

B. State Regulations:

(1) The most important regulatory requirements affecting those responsible for the design, construction and operation of pipelines are State Codes which have, to date, been adopted by 15 states. All of these codes adopted to date pertain to the transmission and distribution of gas only, and do not affect pipelines transporting liquids.

The following regulations are now in effect:

CONNECTICUT—Public Utilities Commission; Docket No. 8612, Feb. 27, 1952; April 14, 1952—

(a) Adopted American Standard Code for Pressure piping, ASA B31.1-1951, supplemented by additional minimum standards.

(b) Code applicable to pipelines subjected to pressures in excess of 100 psig.

(c) A section of pipeline may be constructed under Div. 2 of Sect. 2 subject to permit and provided Div. 1 of Sect. 2 applies to sections within city or borough or within 500' of residence, public building, school, public highway or railroad, and business building for 3 or more employees.

(d) Pipelines subjected to greater than 200 psig shall not be installed within 40' of existing buildings for human occupancy.

(e) Pipelines subjected to greater than 200 psig shall not be laid under a highway or railroad, except to cross. Crossings shall be encased in accordance with A.P.I. Code No. 1102.

(f) Sectionalizing valves at least one for 8 miles.
(g) Not less than 50% of valves over 16" shall be automatic valves.
(h) Automatic and manual blowoff requirements.
(i) Attachment of pipelines to bridges subject to approval of Commission.
(j) (1) Welded assemblies involving other than circumferential welds shall be hydrostatically tested.
(2) Bends in straight pipe may be made if retain full strength.
(3) Branch connection not to exceed 25% of main pipe size.
(4) No mitre welds.
(k) Minimum cover 24". Clearance 12" from substructures. Encase pipe for cover less than 24".
(l) Corrosion protective coating with electrical resistance not less than 50 ohms per 1000 sq. ft. of exposed pipe.
(m) Welding in accordance with A.G.A. specifications for field welding of pipelines.
(n) Leak tests and purging required.
(o) Radiographic testing of 10% of welds.
(p) Pressure shall not exceed certified maximum pressure.
(q) Odorization of gas required.
(r) Cathodic protection if required.
(s) Workmens' safety regulations and construction, operation, and maintenance requirements.

IDAHO—Public Utilities Commission; General Order No. 98, August 1, 1955—

Adopted ASA B31.1.8-1955, with minor exceptions. Sets percentage concentration for odorization and requirements for records and maps, customers' meter testing and recording.

IOWA—Chapter 490, Code of Iowa, 1954, Rules and Regulations Relating to Pipelines, including Statutes, Rules effective April 16, 1934 as re-adopted and revised in 1957—

Construction of pipelines for transmission of gas, operation and maintenance shall be in accordance with Sections 3 and 8 of ASA B 31.1. —1955 or subsequent issues with following added restrictions:

(a) The routing of the pipeline may vary one mile either side of route contemplated in petition for permit from the commission.
(b) Insurance for payment of damages in amount of $50,000.00.
(c) Consent from Highway Authority and Railroad Company for crossings.
(d) Consent of property owner where pipeline passes within 300 feet of occupied residence except in public streets and highways.
(e) Deposit $25.00 or more for expenses for hearing and investigation.
(f) Construction inspection fee $0.50 per mile per inch diameter of pipeline.
(g) Annual inspection fee of $0.25 per mile per inch diameter of pipeline.
(h) Permit carries right of eminent domain for 75 foot R/W and one acre for pumping stations.

(i) Minimum standards for Highway and Railroad crossings, Automatic Valves and Blowoffs.
(j) Accident Reports.

MARYLAND—Regulations adopted by Public Service Commission affect only piping and appliances within buildings or structures. No specific requirements imposed on pipelines.

MASSACHUSETTS—Department of Public Utilities Rules 11725, May 2, 1956—
Requires compliance with ASA B31.1.8-1955 and subsequent revisions, with added requirements. Refers to API Code 1102 for highway and railroad crossings.
D.P.U. 9734, Nov. 30, 1951 and May 2, 1957—proximity to buildings 40 ft. minimum when pressure is 200 psig or more.

(a) More stringent requirements for: testing of welding fittings. Bends made in field, Pressure Taps, and no Mitre Welds.
(b) Highway and Railroad crossings, Corrosion Protection, Leak Tests (hydrostatic or gas), and Air purging.
(c) Welding in accordance with American Gas Association; 10% per mile of welds radiographically tested. Radiographic testing of welds AGA and API.
(d) Valve spacing not less than one valve for eight miles of pipeline. Not less than 50 per cent of sectionalizing valves shall be automatic valves.
(e) Minimum cover 24", 12" clearance from other substructures, and metallic protective shield for cover less than 24".
(f) Cathodic protection commensurate with external coating.
(g) Fluid pressure test.
(h) Compressor station and meter and regulation, station requirements.
(i) Odorization of Gas.
(j) Report accidents immediately and follow in writing.

MICHIGAN—Public Service Commission Orders D3913-56.1 (June 26, 1956); C3913-57.1 (May 27, 1957). Also confirming orders D3913-56.2 & D3913-57.2—

Governs construction and operation of pipelines for transportation of gas, however, does not cover field gathering lines in gas producing or storage fields except where such lines cross highways or railroads.

Adopted American Standard Code for Gas Transmission and Distribution Piping Systems ASA B 31.1.8-1955 with revisions and additions:

(a) ASA 831.33 (b) No. 1-1/4" taps in unreinforced 4" pipe.
(b) Increase minimum cover to 30 inches.
(c) ASA 841.16 add API Code No. 1102, Second Addition, Nov. 1955 for pipeline crossings under railroad tracks.
(d) ASA 841.413 (c) Change to 1.25 times operating pressure.
(e) ASA 842.15 (a) Caulked bell and spigot joints prohibited for new construction.
(f) 842.15 (c) Threaded joints prohibited.

(g) ASA 842.22. Change cover to 30 inches.
(h) ASA 845.33 (b) Change 60 psig to 40 psig.
(i) ASA 845.33 (d) Change 2 psig to 1 psig.
(j) ASA 845.43 (d) Change 2 psig to 1 psig.
(k) ASA 845.51 Change to 1 s sig and 10 psig.
(l) ASA 845.52 Change first sentence to read "---between 10 psig and 40 psig . . ."
(m) ASA 845.53 Change all reference to 60 psig to 40 psig.
(n) ASA 847.11 (a) Change "recommended" to "required."
(o) ASA 847.13 (d) add "The curb box shall be supported independently of the gas service line."
(p) ASA 847.13 add (g) location of shut-off cock.
(q) ASA 847.21 (d) Delete and substitute "Welded joints or compression type fittings shall be used in all underground steel services 1-1/2" in diameter and smaller."
(r) Concerning records and reports.

NEVADA—Public Service Commission—Adopted on May 16, 1957, ASA B31.1.8-1955 as the State Code.

NEW HAMPSHIRE—Public Utilities Commission—Order No. 6075, May 26, 1952.
Adopted as Standard Code the American Standard Code B31.1-1951 Section 2 for pipelines operating at pressure greater than 5 psig.

(a) Gas pipelines for pressures above 100 psig shall fall under Division 2 of Section 2. Under Division 1 if within 125 times diam. of pipe from (a) residence, (b) public building; (c) school grounds; (d) factory employing more than 3 people; (e) public highway or railroad.
(b) Gas pipelines under pressure greater than 300 psig shall not be constructed within 40 ft. of buildings for human occupancy existing prior to construction of pipe line.
(c) Division I. Structural Requirements:
(1) Welded assemblies, not including circumferential welds, shall be hydrostatically tested at least as high as standard code requirement.
(2) Pressure taps, etc., if less than 1/4 size of pipe may be welded in field.
(3) Mitre welds prohibited for pressures greater than 100 psigs.

Road and railroad crossings at approximately right angles only and encased. Min. Depth 4-1/2 feet from top of casing to road surface and 3 feet to bottom of drainage.

(d) Valve spacing for pipelines 16 ins. and under, minimum one in each 20 miles.
(e) Minimum cover 24 inches.
(f) 12 inches min. clearance from other substructures.
(g) Metallic protective shield for pipe with less cover than 24 inches of same thickness of pipe.
(h) Adequate cathodic protection required.
(i) Leak tests required.

(j) Pumping required.
(k) Odorization of transported gas required.
(l) Certification—File Complete Maps.

NEW JERSEY—Department of Public Utilities, Board of Commissioners; Order in Docket No. 6663, March 18, 1953—

Prescribes rules and regulations for construction, operation, and maintenance of pipelines. Requires any gas pipe line subject to internal pressure of 125 psig or more to be constructed and operated in compliance with such standard code as the Board may from time to time prescribe. (The current edition of the Standard Code is ASA B31.1.8-1955).

Regulations prescribed in addition to Code provisions.

(a) Classification: Pipeline operating under 125 psig or more shall be classified under Div (1) or Div (2) of Standard Code and in addition if within 300 feet of residence, etc., and operating at a pressure greater than 500 psig when within 500 feet from residence and shall be classified under Div (1). If operating at pressure greater than 200 psig pipeline shall not be installed within 100 feet of any building for human occupancy already in existence unless such installation is authorized and approved by the Board. Classifications do not apply to buildings of the pipeline owner.
(b) Welding in accordance with A.P.I. and A.G.A. welding specifications.
(c) Quality control of Field Welding: "Welders qualified, pipeline 16" and larger involving 5 miles or more; 20% of welds under Div (1) and 10% of Welds under Div (2) shall be examined radiographically.
(d) Bend straight pipe cold, reinforced openings for branch pipes and mitre welds not to exceed 12-1/2% in pipelines under pressure of 250 psig or less and no mitre welds for pressures greater than 250 psig.
(e) Requirements for roadway and railway crossings and parallel installation (25').
(f) Spacing of valves.
(g) Minimum cover of 2 feet. Encase if less. Minimum clearance of 12 inches from any other substructure.
(h) Meter and regulation station covered.
(i) Odorization of gas, pressure testing.
(j) Accident reports.

NEW YORK—Public Service Commission Case 15686, Applicable to gas only; October 1, 1957. Adopted ASA B31.1.8-1952.

(a) Set up minimum as that applicable to standards for pipelines within cities and villages and for pipelines outside the city or village, if within 300 feet of residence, property zoned residential, building for public gathering, school, building for business employing more than 3 people and 500 feet if pressure is greater than 500 psig. Pipelines to be operated at a pressure greater than 250 psig shall not be installed within 100 feet of any building intended for human occupancy, unless approved by commission.

(b) Field welds shall be in accordance with API-AGA Code, "Specifications for Field Welding and Radiographic Inspection of Pipeline" revised April 1, 1952, tentative. Radiographically test 20% of welds within cities and villages and 10% of welds outside of cities and villages.

(c) Cold bending of straight pipe in field if not stressed in excess of max. provided in code. Mitre bends not to exceed 12 degrees and none allowed for pressure more than 250 psig.

(d) Pipelines crossing under highways for pressures greater than 50 psig and larger than 6" shall be encased and cross at approximately 90 degrees and meet requirements of pipelines within cities and villages of ASA and API Code No. 1102. Minimum cover 3-1/2 feet. If parallel to highway and within 25 feet must conform to the requirements for pipelines within cities and villages, and for railroads, minimum cover, proximity, additional valves for prompt shut-off and possible need for casing.

(e) Valves shall be located not more than 16 miles apart, for pipeline outside of cities and villages where houses are not within 300 ft. of and not more than 8 miles apart where houses are nearer than 300 feet. Within cities and villages valves shall be spaced to provide prompt turnoff in case of emergency. Installation of automatic valves subject to consideration of commission. Require relief valves and vents—semi-annual test and annual internal inspection.

(f) Minimum cover of 24 inches without casing. 36 inches min. cover within cities and villages, 12 inches min. clearance from other substructures. Corrosion protection required including periodic inspection.

(g) Tests required for pipelines operating at pressure greater than 50 psig. Test to 150% of design pressure if within cities and villages, test to at least 50 psig in excess of design pressure outside of cities and villages and not nearer than 300 feet of buildings. Leakage test required in accordance with U. S. Bureau of Mines Bulletin No. 265 "Leakage from High Pressure Natural-Gas Transmission Lines." Purging of Pipelines required within cities and villages.

(h) Pressure Station Requirements.

(i) Odorization of Gas Required.

(j) Report setting forth specifications for construction of pipeline shall be filed with commission; also monthly report of construction progress.

OREGON—Public Utility Commissioner; U-F-1964 Order 34585, May 24, 1956.
Adopted ASA B31.1.8-1955, without modification except filing of records.

WASHINGTON—Public Service Commission; Consolidated Cases Nos. U-8799 and U-8800, June 28, 1955—

Adopted ASA Code No. B 31.1.8-1955 with the following added requirements.

(a) Gas pipelines operating in excess of 500 psig and constructed with less than type C construction shall not be closer than 500' to residences, schools, hospitals, and other buildings.

(b) Gas pipelines operating in excess of 250 psig shall not be constructed closer than 100 ft. of any building intended for human occupancy. Compressor station not to be located in any place zoned for residential use or otherwise restricted by zoning. In other areas compressor stations operating in excess of 250 psig shall not be located closer than 500 ft. of any buildings intended for human occupancy.

(c) Pipelines 6 inch or greater crossing under railroads or highway and operating at pressures greater than 50 psig shall be cased in accordance with API No. 1102 and 6 inches and greater crossing under a road or highway shall be cased if operating at a pressure greater than 125 psig.

(d) Any gas pipeline operated at a pressure greater than 125 psig laid along and within 25 feet of any public highway or railroad shall be at least equal to the requirements of the ASA B 31.1.8. Minimum cover over pipelines shall be 24 inches above top of pipe except where less cover is required to clear substructures then pipe shall be cased. Min. cover 36 inches for class 3 and 4 locations. Min. clearance from substructures 12 inches. Pipelines more than 5 miles in length and 16 inches and over shall have 20% of welds examined radiographically within Class 3 and 4 areas and 10% within Class 1 and 2 areas.

(e) Pipe shall be bent cold.

(f) Shut off valves required for prompt turnoff.

(g) Corrosion control in accordance with A.S.A. Code.

(h) File reports of proposed pipeline and construction progress.

WEST VIRGINIA—Public Service Commission—Rules and Regulations for the Government of Gas utilities, March 1, 1956.

No rules and regulations applying to pipeline construction and operation are in force. Construction and maintenance of plant and equipment shall be in accordance with ASA B31.1.8-1955.

WISCONSIN—Public Service Commission, Chapter PSC135 - 2-U-3829 - September 5, 1952; Interim Gas Safety Rules and Regulations.

Does not at present have rules and regulations governing construction of gas pipelines. Presently considering adoption ASA B31.1.8-1955, with some deviations.

VIRGINIA—has adopted ASA B31.1.8-1955 for regulation of highway crossings and parallel occupancy of highway right-of-way.

(2) No codes reported in the following states: ALABAMA, ARIZONA, ARKANSAS, CALIFORNIA, COLORADO, DELAWARE, FLORIDA, GEORGIA, ILLINOIS, INDIANA, KANSAS, KENTUCKY, LOUISIANA, MAINE, MINNESOTA, MISSISSIPPI, MISSOURI, MONTANA, NEBRASKA, NEW MEXICO, NORTH CAROLINA, NORTH DAKOTA, OHIO, OKLAHOMA, PENNSYLVANIA, RHODE ISLAND, SOUTH CAROLINA, SOUTH DAKOTA, TENNESSEE, TEXAS, UTAH, VERMONT, WYOMING.

(3) In almost all—if not all—states, permits must be obtained from the State Highway Department for pipeline crossings or for parallel

occupancy of highway rights-of-way; such permit usually containing or having appended thereto conditions affecting design and/or construction.

(4) Certain states, particularly in the far west, with large holdings or public lands, issue indentures or lease rights-of-way for pipelines. Typical California, Arizona, and Utah documents examined did not contain any requirements or restrictions affecting the design or construction. A New Mexico permit did require a 20-inch minimum depth of bury.

C. Minor Governmental Subdivisions:

(1) Franchise Ordinances—Many counties and municipalities require the passage and adoption of franchise ordinances to "construct, maintain, and operate pipelines in and across public highways" within the boundaries of that county or municipality. Stipulations within the franchise vary widely, but usually do not contain conditions of more than minor import insofar as the pipeline engineer is concerned.

(2) Zoning Ordinances—Zoning, not only in urban areas but also in semi-rural sections near metropolitan areas, is increasingly prevalent. Several pipeline companies have reported unexpected and costly delays in construction due to lack of knowledge of local zoning requirements. These requirements usually concern only the location and rarely affect pipeline design or operation.

(3) City Codes—The only municipal code reported is that in effect in New York City.

The New York City Administrative Code provides that the Commissioner of the Department of Water Supply, Gas and Electricity shall be responsible for regulating water and gas in the City of New York. Under this authority the Department has established "Regulations, Construction Standards and Requirements for the Installation of Natural Gas Steel Mains in the City of New York."

These regulations are voluminous and govern all phases of design and construction, including—

(a) Limitation of operating pressures not to exceed 400 p.s.i.
(b) Permits, approvals, record drawings, etc.
(c) Specifications for excavation, backfilling, rock shields, etc.
(d) Coating materials and application, holiday detectors, field tests and inspections, cathodic protections, etc.
(e) Welding materials, equipment, procedures, welder qualifications, radiographic inspection, etc.
(f) Specifications and requirements for valves and valving.

Other municipalities may have codes or regulations affecting pipeline design and construction to varying degree.

Respectfully submitted,

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Task Committee on Investigation of Problems Involved in Regulation of Pipeline Design and Construction by Various Governmental Agencies of the Committee on Pipeline Design, Specifications and Operating Standards of the Pipeline Division.

Journal of the
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THERMAL ELECTRIC PIPELINE FOR HIGH-VISCOSITY FUEL

A. G. Purdue[1]

ABSTRACT

The use of vacuum still bottoms as primary energy source in a thermal generating station is described, with emphasis upon the method of pipeline transport of this material from a nearby refinery to the new 100,000 KW Central Sur Station of the Puerto Rico Water Resources Authority at Guayanilla, P. R.

A modern electrical generating facility has recently been constructed on the South Coast of Puerto Rico by the Autoridad de las Fuentes Fluviales (Water Resources Authority). The primary energy source for this 100,000 KW installation is vacuum still bottoms used as HiVis fuel, a material which heretofore has been regarded as too viscous at readily maintainable temperatures for pipeline transport to an outside consumer. The determination of the Autoridad to make the most efficient use of available resources has resulted in the design of an automatic high-temperature delivery system to supply Hi-Vis to their steam generators. This pioneer venture has shown that a large thermal potential, which until now has been inefficiently employed, can be made available by advanced techniques of fuel handling and storage. The following description of the installation will be of special significance to those concerned with the most effective use of petroleum resources for power generation.

It is a safe prediction that the demand for thermally generated electric power will continue its present rise into the next decade and beyond. The most optimistic forecasts for the future of synthetic energy sources only give further reason to believe that natural petroleum fuels will carry the base load of the world's energy requirements for years to come. This predictable increase, coupled with changing world conditions which may result in a

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1. Fluid Systems, Inc., New Haven, Conn.

redistribution of petroleum reserves, makes it imperative that ways be found for getting the maximum energy usage out of each barrel of crude produced.

It is equally safe to conclude that the demand for lighter distillates, for high-quality, special purpose gas and liquid fuels, will continue to increase. From the standpoint of refinery economics it is especially important that these constituents be extracted in the greatest possible yield. If a refinery could do nothing but convert every barrel of crude into a barrel of fuel oil to be sold at market prices, the result would be an overall loss. The lighter distillates must be sufficient in quantity to offset this loss and to show a profit.

These two demands—the need for more thermal power and the market for lighter distillates—are somewhat in conflict. The reasoning behind this statement is not difficult to follow. Most existing power generators which burn liquid fuel use a product that can be stored in tanks and pumped through delivery lines at moderate temperatures. When, however, the maximum yield of volatile hydrocarbons is extracted from crude oil, the viscosity of the residue becomes so high that it can neither be stored nor pumped at moderate temperatures and so it is not directly useable by a majority of existing facilities for power generation. In fact, when the distillation process is carried to the extreme yield point, the residue is a tarry solid at ambient temperatures. This material, variously called tar pitch, vacuum still bottoms or HiVis fuel, is all but unmanageable by the usual techniques for fuel handling and storage. Bottoms used as HiVis fuel will be called HiVis hereafter.

HiVis represents a very considerable fraction of each barrel of crude—20 to 30 per cent, depending upon the source of crude and the fractionation process. Its physical properties cannot be precisely specified because they vary according to the throughput schedules of the refinery. While a liquification temperature of about 250° F. is typical, and the material usually flows readily at about 350° F., only at still higher temperatures in the vicinity of 450° F. can it be burned. The following table taken from tests upon a particular sample of HiVis shows the general variation of viscosity with temperature:

Temperature	SSU Viscosity
122° F.	12,000,000
250	12,000
300	2,000
350	540
400	280
450	150

HiVis is high in sulfur content but it is not chemically active or corrosive below 500° F. The free carbon content is high—15-25% may be a typical range, but as ordinarily produced it is free from particle aggregates and dirt of the nozzle-blocking variety. A high flash point permits safe handling at the temperatures at which the material can be pumped.

The significant property of HiVis from the standpoint of this discussion is that it is a good fuel. On a pound-for-pound basis the heating value is not inferior to that of the bunker oils in general use; its luminosity characteristics contribute to a high generator efficiency. The problem is to deliver this highly variable material to the burner nozzles in useable condition. In the absence of a generally serviceable solution to the transport problem, the use of HiVis fuel is indeed limited.

Dispositions made of the large heat potential of HiVis are often unsatisfactory from both the short-range and the long-range points of view. At times it has been regarded as a pure waste product to be disposed wherever it would not create a pollution problem. This may make sense from the standpoint of a specific refinery operation but it is hardly a satisfactory general solution. Another possibility is the non-fuel use of HiVis such as blending it into surfacing materials. This offsets production costs but has nothing to do with the efficient use of thermal potential. A common alternative is to blend vacuum still bottoms back into lighter distillation products in such proportion that the result is not below grade for fuels that can be handled by standard burner equipment. Here arises a quite undesirable restriction upon the operating decisions of a refinery. The distribution of products, which ideally should be determined by relative demands, must instead be determined by what is available.

It would certainly be advantageous to have a direct use for HiVis in whatever quantity it happened to be available. The sale on a BTU basis would represent the greatest value to both supplier and consumer. The additional degree of freedom in refinery management would leave it free to respond to market demands. All factors considered, it appears most desirable to find solutions to the handling and storage problems in order to use the superior qualities of this fuel.

Supposing that a large potential consumer of HiVis is located in the vicinity of a petroleum refinery, it becomes worthwhile to consider the possibility of piping the hot fuel directly to the user. The important consideration is the distance between facilities. While a very short run of 450° F. - 500° F. pipeline presents no insurmountable problems, a run of even moderate distance is beset with difficulties. Let us consider the requirements upon the line to get an idea of the problems to be solved.

First, because HiVis is produced continuously with little or no storage available at the producer's end, the line must be completely reliable. The material delivered may vary over quite wide ranges in its thermal characteristics. The line must maintain constant flow conditions regardless of these variations. It must be equally adaptable to conditions of flow and non-flow. Whatever the temperature and rate of delivery, it must maintain pumpability for the full length of the run. Last and very important, it must have sufficient reserve capacity to recover the complete handling facility following a freeze-up and to attain pumpability in a reasonable length of time. These requirements are expensive and difficult to meet when approached by ordinary techniques suited to less demanding materials.

The situation described above—the proximate location of a refinery and a generator—is that which was encountered in the construction of the Central Sur Generating Station of the Puerto Rico Water Resources Authority. The potential supplier of HiVis was the refinery of the Commonwealth Oil Refining Company located about a mile distant from the generator site. This refinery has sufficient HiVis output to serve as primary fuel for the normal 100,000 KW load upon the station and can also supply alternate fuels in any needed quantity. Accordingly, the station was designed to burn any combination of HiVis and bunker C oil.

Fig. 1 is an aerial photograph showing the nearly completed station in the foreground and the refinery in the distance. Immediately behind the station is the 150 KV switchyard which feeds into the integrated network that serves the growing domestic and industrial needs of the island.

The arrows in Fig. 1 indicate the course of the fuel line by which the refinery feeds the four storage tanks (light-colored tanks in right foreground) and the pumping area which makes delivery of HiVis to the station. This pipeline has just been described as one whose construction and operation by ordinary techniques would be quite difficult. But here these difficulties have been overcome. The explanation lies in the fact that this is not a conventional pipeline. It is a Thermal Electric line, and this calls for a few words of definition.

Thermal Electric is a recent development for heated pipeline transportation of highly viscous materials. Given the problem of electrical heating of a pipeline, the Thermal Electric principle is to use the reactance of the pipe itself to transform electrical energy into heat in a manner which can be closely regulated. By governing the rate of energy inflow so as to balance exactly the rate of thermal loss, fluid flow conditions are brought close to the ideal. By maintaining a constant temperature along the length of the pipe, thermal exchanges between the fluid and the pipe wall are minimized, flow conditions and load upon the pumping station are held constant. Since the correct conditions of energy supply can be attained in practice, it is clear that the principle being discussed is physically sound.

Looking at the idea from the engineering point of view, further advantages quickly become apparent. One of the foremost is that standard schedule piping

FIGURE 1. FACILITIES LINKED BY THERMAL ELECTRIC PIPELINE

can be heated with readily available values of currents and voltages. Other positive values are found when the Thermal Electric method is compared with other ways for achieving the same result.

Some of these points might be illustrated by a few comparisons between the Thermal Electric idea and a steam-jacketed line. Here the purely mechanical advantages of the electrical system are quite clear. It is required that the whole line be recoverable in case of freeze-up. This implies a large allowance for thermal expansion and if a jacket is used, there must be provision for differential expansion of jacket and conductor. Operation at up to 500° F. temperature implies a fair pressure and the requirement for rapid recovery requires a large circulating steam capacity. Obviously the materials and engineering cost for a steam line of any length will be high. The Thermal Electric line in the same service, on the other hand, will have provision for large expansion consisting of sizeable expansion bends, but otherwise will be insulated, standard schedule piping.

The electric line fares even better in the comparison of thermal efficiency. Remembering that only a portion of the superheat of the steam is useful, it is imperative that the condensate be returned with minimal heat loss. Here we have another line at fair pressure and temperature. Of course, the Thermal Electric counterpart also requires a return. However, a very moderate cross-section of copper or aluminum will return currents of the required magnitude with negligible loss.

The whole cross-section of the Thermal Electric line consists of fluid, pipe and the covering which serves as both thermal and electrical insulation. (It should be noted here that only very moderate electrical potentials are required for pipe-heating, the insulation being for off-ground purposes only.) The resultant diameter and surface area per unit of length are small as compared with a steam line. So are the direct thermal losses to the atmosphere, because both convective and radiant losses vary with area.

While arguments of the above kind are useful in establishing the merits of a working principle, from the practical viewpoint this fact is more important; Thermal Electric is more than an abstract principle; it is a highly developed engineering method. The best way to convey a useful idea of what this method is and what it can do is by describing the step-by-step approach to designing a complete system.

A Thermal Electric design is undertaken in the following sequence.

1. Working from preliminary design data and the overall performance specifications for the transport and storage system, Thermal Electric engineers determine the heating requirements for each portion of the system—transmission, storage, and end-use segments. On the basis of these findings the system is analyzed into portions which are to be separately temperature-controlled and energized. This division into parts is governed partly by mechanical considerations and partly by the desirability of working within certain ranges of supply voltages and currents.
2. A mechanical design is drawn up, the problems of detailing having largely been solved in advance by Thermal Electric designs for insulating and isolating hardware which are adaptable to any likely combination of temperature and pressure conditions and which offer predictable electrical performance.

3. The reactances of all the separate portions of the system are computed with reference to extensive tables of empirical data resulting from research upon a wide variety of pipe materials and configurations, and the variations in their characteristics over the involved temperature ranges.
4. An electrical supply system is synthesized with regard for reliability, safety and freedom from overhead cost. The guiding idea here is to attain automation of operation—so that the final system adapts to all conditions of flow or non-flow and to variations in ambient conditions without attention from operating personnel. Other important objectives are to group for easy accessibility all controls which for one reason or another have not been eliminated, and to arrange for simple and complete inspection of the electrical system. In addition, full provision is made for protection of electrical equipment in case of unforseeable damage to any part of the system.
5. A last step is especially critical; it is that of following up the design and supply of compatible apparatus by on-the-job engineers to insure a fully functional system from the beginning. This has frequently resulted in the avoidance of costly errors by construction personnel, many of whom fail to appreciate the dual role of fluid conduction and current conduction in a single element. There is no substitute for the experience and instruction that highly-trained field engineers can offer in the course of construction. The result of this policy is that Thermal Electric systems work on schedule and do not cost expensive delays in operation.

It is beyond the scope of this paper to describe the construction of the Thermal Electric System in detail, but some of the salient features of the Puerto Rican installation are worthy of mention.

Power is supplied to the pipe and storage elements by a total of seventy-five energizing units, thirty-four of which are applied to the tanks, the rest being distributed along the length of the run. Each energizer is post-mounted along with its thermostatic control element. The primaries of the energizers are supplied with 480 V, 60-cycle current by underground conduit. The main power is furnished by a small substation and a switch panel from which energizers may be controlled individually or in banks. This substation is normally operated at a fraction of its nameplate rating because of the cyclical function of the energizers. It has sufficient reserve capacity to ensure start-up from a frozen condition.

The heating of the storage tanks was an important part of this job. Three tanks of 180,000 gallons capacity and one 70,000 gallon tank are held at 450° F. so that full flow at burning temperature is immediately available. Heating elements and energizers here are individually controlled and energized loops of 2-1/2" piping, ten in each of the larger storage units and four in the smaller. Fig. 2 shows the arrangement of energizers and thermostat switches applied to the tanks. Terminals of the coils are seen protruding through the tank wall from which they are insulated by special hardware. Above the coil terminals on the tank wall are the explosion-proof thermostat control boxes. Each of the Energizer units on the framework at the right in the picture supplies current to one of the independent heating coils. The assembly which permits electrical feed through the tank wall without metallic contact is a Thermal Electric development which has been proven in many kinds of service.

This internal arrangement of heating elements results in a very uniform temperature distribution within the tank, with exact control of the skin temperature of the coils, not influenced by surrounding fuel temperature. Incidentally, the area shown in this picture is classified as Class I, Group D, Division 2. Thermal Electric apparatus can be designed to meet any combination of safety regulations and introduces no electrical hazard in a situation like this.

HiVis is pulled from the storage units by three pumps for a delivery capacity of 200 gallons per minute. The pump bodies are maintained at 350° F. by means of radiant heaters. These are small units because they are only required to offset minor losses. The control of temperature is achieved by cycle timers.

HiVis control piping inside the station is practically identical with that for the low-temperature alternate fuel. In this portion of the installation, Thermal Electric energizers are grouped "below deck" to reduce congestion in working areas, and as in the case of the pumps, radiant heaters are used for temperature maintenance of control valves.

Experience has shown that no extra effort on the part of operating personnel is occasioned by the use of HiVis fuel as compared with standard fuels.

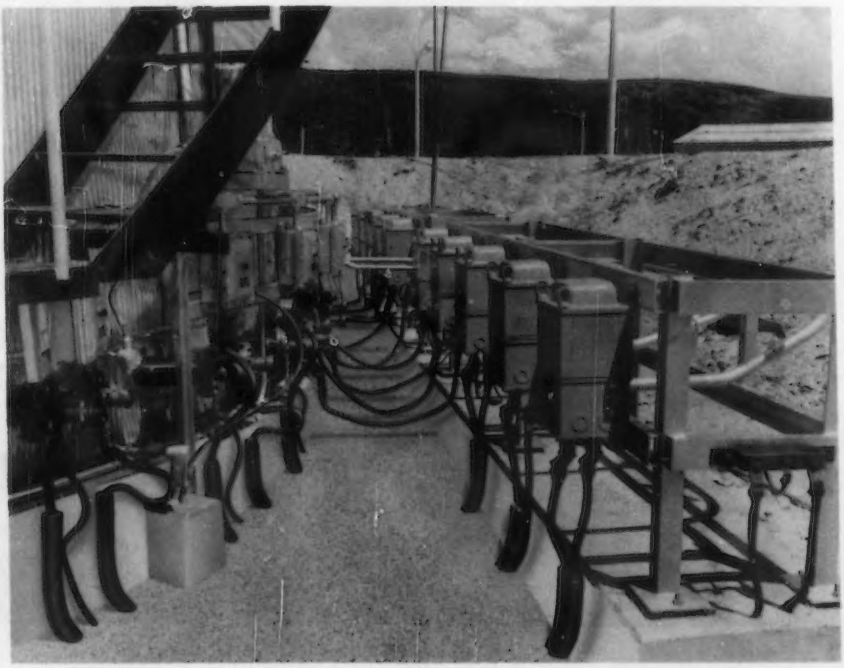

FIGURE 2. VIEW OF TANK BASE SHOWING HEATING ARRANGEMENT

Fuel changeover is accomplished with ease from the ultra-modern control room of the station. Fig. 3, a photograph of the control room, shows the television panel from which the engineer can observe several functions of the system including the condition of his fires by direct view into the furnaces.

The combination of facilities that we have shown here is a significant factor in the industrial and economic life of Puerto Rico. The population problem and the resulting need for industrial growth in this territory are familiar to everyone. The Water Resources Authority, staffed entirely by Puerto Rican personnel educated in island and state-side institutions, over a period of many years, has planned and carried out full utilization of the hydroelectric potential of the island. Having borne the responsibility for foreseeing the future power needs of their country, they realized at an early date that the base load must eventually fall upon thermal generation. Their wise planning has resulted in a sufficient supply of energy for the large enterprises which are finding the island location advantageous. The station shown in the picture is the latest addition to the well-balanced power structure of the island and it is an accomplishment of which the Puerto Rican people can be proud. Likewise, the engineers of Fluid System*, Incorporated, originators and designers of the

FIGURE 3. CONTROL ROOM OF CENTRAL SUR POWER STATION

*Thermal Electric and Fluid Systems are registered trademarks.

Thermal Electric* Method, are proud to have played a part in this significant enterprise.

*Thermal Electric and Fluid Systems are registered trademarks.

Journal of the
PIPELINE DIVISION
Proceedings of the American Society of Civil Engineers

EXISTING POLICIES RELATIVE TO PIPELINE LOCATION

Progress Report of the Committee on Pipeline Location
of the Pipeline Division

ABSTRACT

This report is a summary of answers to a series of eight questionnaires sent to about 100 pipeline companies regarding their pipeline location policies. These queries covered the subjects of road and other crossings, loop line spacing, population density, depth of cover, underground mineral deposits, and swamps.

This report was prepared for the information of pipeline engineers and to obtain widespread discussions.

Questionnaires on existing policies relative to pipeline location were sent out in 1957. Out of a miling list of about 100, replies were received from 51 natural gas pipeline companies, 20 crude oil and products pipeline companies, and 20 municipalities (water and sewer).

These questionnaires were eight in number and request was made to the addressees to give their answers by checking the forms and to enlarge their answers with comments under the space provided for "remarks."

The questionnaires covered the following subjects and are briefly summarized:

No. 1. Angle of intersection of pipeline and center line of various types of roads—economics usually favor the shortest feasible crossing where boring and casing are required.

No. 2. Construction with reference to the ASA B31.1.8 - 1955 Code for Pressure Piping for gas transmission systems and effect of population density indices (which indices anticipate some increase in population density in all areas after a line is constructed)—a higher type of construction is preferred to relocating a proposed line.

Note: Discussion open until October 1, 1959. To extend the closing date one month, a written request must be filed with the Executive Secretary, ASCE. Paper 2039 is part of the copyrighted Journal of the Pipeline Division, Proceedings of the American Society of Civil Engineers, Vol. 85, No. PL 2, May, 1959.

Minimum distance standards to buildings intended for human occupancy can be prohibitive and have no relation to future growth.

No. 3. Minimum cover in soil and rock—24" to 30" is usually specified in soil and less in rock, with increases largely due to subsoil plowing and land leveling, or as requested by land owners.

No. 4. (a) Crossings over or under cables and lines—the custom is to cross under other facilities depending on the relative grade; clearance requirements usually range from 12" to 24". Also, (b) half of the reporting companies never use extra cover in lieu of weights.

No. 5. New line location—this is usually controlled by future looping and seldom controlled by landowners' preferences. Line changes depend on costs and good public relations.

No. 6. Effect of mineable underground mineral deposits on re-routing or future protection measures—re-route for large deposits; pay for minerals when worked in the area or move the line.

No. 7. Re-routing around swamps, bogs, and other inaccessible areas—only if no additional cost is incurred. Also, it is not a general policy to build work roads in inaccessible areas.

No. 8. Spacing between loop lines—the spacing increases with line diameter, particularly for gas pipelines, and is less in populated areas.

In general, the best route is selected initially based on good engineering principles for safety with respect to the public. Each special location problem is usually considered on its own advantages and disadvantages with consideration to comparable investments and operating costs.

Answers were tabulated to eliminate detail. In some cases certain questions were unanswered and, in others, more than one specification was indicated, which resulted in the lack of correlation between companies reporting and the totals in each category. The wording, as used in the questionnaires, is repeated in the tabulations. An attempt was made to summarize the numerous remarks with no opinions other than those expressed in the responses.

The Committee feels that the policies indicated by this report should be further explored by queries to pipe line rights of way groups and pipe line contractors to obtain a more complete concept of the subjects under consideration.

Respectfully submitted,

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Joseph B. Spangler
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Committee on Pipeline Location of the Pipeline Division

Summary of Tabulations and Remarks
Questionnaire No. 1

About half of the natural gas, crude oil and products pipeline companies cross unimproved dirt and gravel roads at whatever angle the pipeline happens to intersect. However, a significant number indicated that they did not cross such roads at less than a 45° angle. Unimportant roads, which do not require casing, are crossed at the angle they intersect, particularly with lines 16" and larger.

On secondary and primary paved roads, the majority cross as close as possible to right angles, and almost all at an angle of intersection of not less than 45°. Crossing angles on these types of roads are sometimes regulated by a government body. Due to the added difficulties and costs of boring and casing, economics usually favor the shortest feasible crossing consistent with right of way and terrain limitations and the length of bends required to permit pigging operations.

With municipalities, since nearly all water and sewer mains are parallel to the streets and roads under the easement or pavement, crossings of cross streets or roads are usually at the normal right angle intersections. Crossings are sometimes made at acute angles to avoid other subsurface structures and, in instances where two streets do not intersect at a right angle, the pipelines cross at the same angle as the streets except under primary roads requiring casing. Although a good number of replies indicated crossing roadways at whatever the angle of intersection might be, many of the replies were qualified in the comments by a statement that nearly all such intersections were at right angles.

Summary of Tabulations and Remarks
Questionnaire No. 2

Nearly all of the natural gas pipeline companies reporting have constructed pipelines since the ASA B31.1.8 - 1955 Code of Pressure Piping was published and all but one company used it as a basis for design as minimum requirements. Local or state codes sometimes have superseded this Code.

Most of the companies preferred to use a higher type of construction due to population density rather than to relocate a proposed line.

Most of the companies have a minimum standard distance of 100' or more specified from buildings intended for human occupancy which is generally followed. Most report that using a higher type of construction is more practical since this takes into account future growth. When the distance concept is used, a minimum distance standard can be prohibitive in some locations and there is no control on what happens after the line is built. Several report that buildings have been built close to their lines and one company reports the problem of developers using the right-of-way as streets and constructing houses parallel to the right-of-way. Another company, with 60' rights-of-way for its 20" and larger lines, has been taking a right-of-way with a "no building or structure" clause for a distance of 30' on either side of the completed pipe line and, in trying to maintain this distance, has taken some cases into court but has had to settle previous to actual trial because it was unable to get a court decision on this distance.

TABULATION OF ANSWERS TO QUESTIONNAIRE NO. 1

For lines constructed in the past five (5) years, what has been your company's policy in regard to the angle at which road crossings were made?

	Angle of Intersection of Pipeline and Centerline of Road				At whatever angle pipeline happens to Intercept
	Right Angle	At angle of not less than: 60°-85°	45°-50°	30°-40°	
1. Unimproved dirt roads					
A. Natural Gas Pipelines	14	4	5	1	24
B. Crude Oil and Products Pipelines	3	2	5	1	10
C. Municipalities (Water and Sewer)	13	1	1	-	8
2. Graded gravel roads					
A. Natural Gas Pipelines	17	7	7	1	12
B. Crude Oil and Products Pipelines	3	3	5	1	10
C. Municipalities (Water and Sewer)	13	1	1	-	6
3. Secondary paved State or County roads					
A. Natural Gas Pipelines	23	10	5	1	6
B. Crude Oil and Products Pipelines	4	6	6	1	5
C. Municipalities (Water and Sewer)	13	1	1	-	7
4. Primary paved Federal State or County roads					
A. Natural Gas Pipelines	28	10	2	1	7
B. Crude Oil and Products Pipelines	4	6	6	1	4
C. Municipalities (Water and Sewer)	13	1	-	-	4

TABULATION OF ANSWERS TO QUESTIONNAIRE NO. 2

Applicable only to Natural Gas Pipelines	Yes	No
1. Has your company constructed any pipelines since the publication of the ASA B31.1.8 - 1955 Code?	47	4
If answer is yes:		
(a) Was the line design and location in accord with the Code?	46	1
(b) Did the Population Density Indices cause the line to be relocated or a higher type of construction to be used?	35	11
(1) What was done? Relocation - 12; Higher type of construction - 33		
2. Does your company have a minimum distance standard for lines in the vicinity of buildings intended for human occupancy?	34	14

(a) What is the distance?

16' to 40'	4
50'	6
100'	12
200'	5
300'	6
500'	1

(b) Is this standard followed?

Always	8
Generally	25

One company reports that in Class 3 and 4 locations it is impossible to maintain a minimum distance, since these areas involve subdivided and developed property, with construction at the edge of the city's street right-of-way. In most of these cases distance is determined by fire codes and building codes which govern the building location with reference to property lines.

Summary of Tabulations and Remarks
Questionnaire No. 3

The majority of natural gas pipeline companies reported a minimum cover of 30" in soil, with 24" or less in rock. The majority of the reporting crude oil and products pipeline companies specify a minimum cover of 20" to 24" in soil, and 12" or less in rock. Municipalities (water and sewer) reported a minimum cover in soil in the 30" range, but not less than 20". Only a small percentage of these municipalities had rocky conditions and the specifications were the same as in soil.

Most companies indicated no appreciable increase in cover requirements during the past five years.

Where cover has been increased or contemplated, such increase is largely due to subsoil plowing, potential land leveling, and at landowner's requests. In some such cases cover is sometimes increased to 40" or more.

TABULATION OF ANSWERS TO QUESTIONNAIRE NO. 3

1. What are the usual minimum specifications of your company regarding cover over the pipeline?
(Not at road, streams or other special areas)

	In soil	In rock
A. Natural Gas Pipelines		
(1) 12" or less	-	4
(2) 18" - 20"	1	6
(3) 20" - 24"	10	22
(4) 28" - 30"	31	13
(5) 36"	7	2
(6) 40" and over	4	-
B. Crude Oil and Products Pipelines		
(1) 12" or less	-	10
(2) 18" - 20"	4	2
(3) 20" - 24"	10	2
(4) 28" - 30"	-	-
(5) 36"	1	1
(6) 40" and over	-	-
C. Municipalities (Water and Sewer)		
(1) 12" or less	-	-
(2) 18" - 20"	1	-
(3) 20" - 24"	-	1
(4) 28" - 30"	11	3
(5) 36"	7	3
(6) 40" and over	-	-

2. Has the general cover requirement been increased during the past five (5) years?

	Yes	No
A. Natural Gas Pipelines	7	39
B. Crude Oil and Products Pipelines	6	8
C. Municipalities (Water and Sewer)	4	13

Summary of Tabulations and Remarks
Questionnaire No. 4

The custom with natural gas, crude oil and products pipeline companies is to cross under other facilities; however, the relative grade is the controlling factor. Some telephone companies prefer to have their cables under pipe lines and will lower their cable if possible.

In a few cases the clearance when crossing other pipe lines, cables, sewers, and drain tiles is 6", but the majority require 12" clearance.

TABULATION OF ANSWERS TO QUESTIONNAIRE NO. 3 (Contd.)

3. If the general cover requirement has been increased or the company contemplates such an increase on future work, indicate the reason or reasons which you believe to be reasonable:

	A Natural Gas Pipelines	B Crude Oil and Products Pipelines	C Municipalities (Water and Sewer)
(a) Higher line pressures	5	1	1
(b) Larger pipe diameters	7	2	-
(c) Sub-soil plowing	17	8	-
(d) Potential landleveling	12	3	1
(e) Potential field drain tile	6	2	-
(f) Potential open ditch irrigation or drainage	6	3	-
(g) State or local codes	8	2	-
(h) Insistance of land owners	9	6	-

The majority require 24" to 36" clearance under drainage ditches, minor streams, and road ditches.

About half of the gas and oil pipeline companies never use extra cover in lieu of weights.

Municipalities (water and sewer) all replied that their policy is to cross over or under other lines depending on the relative grades. Clearance as low as 4" was noted in one case with 12" to 24" in the majority. However, clearances were increased to 24" to 36" under drainage ditches, minor stream beds, and road ditches. The use of additional cover in lieu of weights has occasionally been done.

Summary of Tabulations and Remarks
Questionnaire No. 5

The majority of natural gas pipeline companies usually let the possibility of future looping control new line location and seldom allow landowners' preferences control a new line location. The gas pipeline companies are more concerned with future looping than the reporting crude oil and products pipeline companies and frequently obtain second line rights when possible.

In determining whether or not to comply with a landowner's request for a line change, reasonable effort is made to consider his request in view of the cost of the line change compared to less costly rights-of-way and additional operating and maintenance cost for the added length of line. Most companies remarked that if construction is in progress, the consideration of possible delays becomes most important.

The use by municipalities (water and sewer) of private rights-of-way is extremely limited. Good public relations is their important consideration in line changes.

TABULATION OF ANSWERS TO QUESTIONNAIRE NO. 4

1. In the case of crossing underground cables, pressure pipelines, sewer lines, etc. is it your company's general policy to go:

	Over the existing facility	Under the existing facility	Over or under depending on the relative grades of the two
A. Natural Gas Pipelines	2	20	27
B. Crude Oil and Products Pipelines	-	4	6
C. Municipalities (Water and Sewer)	-	-	11

2. What is your company's general specification for clearance between their pipelines and the following:

	3" - 4"	6" - 12"	18" - 24"	30" - 36"
(1) Other pipelines				
A. Natural Gas Pipelines	1	31	12	-
B. Crude Oil and Products Pipelines	-	11	4	-
C. Municipalities (Water and Sewer)	1	6	1	-
(2) Underground Telephone Cables				
A. Natural Gas Pipelines	-	33	8	-
B. Crude Oil and Products Pipelines	-	8	4	1
C. Municipalities (Water and Sewer)	-	7	1	-
(3) Sewers				
A. Natural Gas Pipelines	1	31	8	1
B. Crude Oil and Products Pipelines	-	9	4	-
C. Municipalities (Water and Sewer)	-	5	3	1
(4) Field drain tile				
A. Natural Gas Pipelines	-	29	7	-
B. Crude Oil and Products Pipelines	-	9	4	1
C. Municipalities (Water and Sewer)	1	4	2	-

TABULATION OF ANSWERS TO QUESTIONNAIRE NO. 4 (continued)

	3" - 4"	6" - 12"	18" - 24"	30" - 36"
(5) Bottom of drainage ditches				
A. Natural Gas Pipelines	-	4	14	16
B. Crude Oil and Products Pipelines	-	2	7	5
C. Municipalities (Water and Sewer)	-	-	6	1
(6) Bottom of minor streams				
A. Natural Gas Pipelines	-	1	11	27
B. Crude Oil and Products Pipelines	-	2	3	8
C. Municipalities (Water and Sewer)	-	1	4	3
(7) Bottom of road ditches				
A. Natural Gas Pipelines	-	2	16	27
B. Crude Oil and Products Pipelines	-	-	7	7
C. Municipalities (Water and Sewer)	-	1	5	-

3. Does your company use extra cover on pipelines in certain areas in lieu of weights where there is some possibility that the pipeline might otherwise float up?

	Often	Occasionally	Never
A. Natural Gas Pipelines	4	16	24
B. Crude Oil and Products Pipelines	1	6	7
C. Municipalities (Water and Sewer)	1	3	5

TABULATION OF ANSWERS TO QUESTIONNAIRE NO. 5

1. To what degree does your company let the possibility of future looping control new line location?

	Always	Usually	Seldom
A. Natural Gas Pipelines	7	23	12
B. Crude Oil and Products Pipelines	2	3	9
C. Municipalities (Water and Sewer)	5	3	2

2. To what degree does your company allow landowner's preference control new line location?

	Usually	Seldom
A. Natural Gas Pipelines	14	28
B. Crude Oil and Products Pipelines	6	7
C. Municipalities (Water and Sewer)	-	9

3. In determining whether or not to comply with a landowner's request for a line change, does your company base their decision on:

(a) Maintaining good public relations with the landowner?

A. Natural Gas Pipelines	22
B. Crude Oil and Products Pipelines	10
C. Municipalities (Water and Sewer)	7

(b) Cost of line change compared to less costly rights-of-way?

A. Natural Gas Pipelines	18
B. Crude Oil and Products Pipelines	8
C. Municipalities (Water and Sewer)	3

(c) Cost of line change compared to less costly rights-of-way and consideration to additional operating and maintenance cost for the added length of line?

A. Natural Gas Pipelines	26
B. Crude Oil and Products Pipelines	6
C. Municipalities (Water and Sewer)	3

(d) Possible delay of line construction schedule?

A. Natural Gas Pipelines	16
B. Crude Oil and Products Pipelines	7
C. Municipalities (Water and Sewer)	-

Summary of Tabulations and Remarks
Questionnaire No. 6

Many of the pipeline companies reported no experience with underground mineral deposits.

The majority of natural gas pipeline companies, who supplied information, do not re-route for small deposits but do re-route for large deposits. Most agree to pay for minerals on the right-of-way if and when minerals are worked in the area, or move the line.

TABULATION OF ANSWERS TO QUESTIONNAIRE NO. 6

1. In cases where the preferred pipeline location crosses mineable underground mineral deposits that are usually blasted in the process of removal, which of the following conditions best describe your company's policy?

	Yes	No
(a) Is the line re-routed for small deposits?		
A. Natural Gas Pipelines	7	17
B. Crude Oil and Products Pipelines	6	4
(b) Is the line re-routed for large deposits?		
A. Natural Gas Pipelines	21	5
B. Crude Oil and Products Pipelines	9	1

2. In cases where the preferred pipeline location crosses mineable underground mineral deposits that <u>are not</u> usually blasted in the process of removal, which of the following conditions best describe your company's policy?

(a) Is the line re-routed for small deposits?		
A. Natural Gas Pipelines	5	20
B. Crude Oil and Products Pipelines	4	6
(b) Is the line re-routed for large deposits?		
A. Natural Gas Pipelines	18	9
B. Crude Oil and Products Pipelines	8	2

3. If the line location is left unchanged, which of the following measures does your company take for future protection of the line?

(a) Purchase all mineral rights on Right-of-Way?		
A. Natural Gas Pipelines	4	13
B. Crude Oil and Products Pipelines	1	5
(b) Agree to pay for minerals on the Right-of-Way if and when they are worked in the area?		
A. Natural Gas Pipelines	12	5
B. Crude Oil and Products Pipelines	1	4
(c) Move line if and when minerals are worked in area covered by Right-of-Way?		
A. Natural Gas Pipelines	12	8
B. Crude Oil and Products Pipelines	6	1

Several gas pipeline companies report that sand and gravel deposits, which normally do not require blasting, have caused greater troubles than other mineable deposits, and re-routing is the only recourse when safety is impaired. Another reports its worst problem is coal stripping and attempts to avoid crossing these areas. In another area, a company reports that building materials, such as stone, gravel, and cement clay, of low unit value, are encountered and that mutually satisfactory arrangements can usually be worked out with those landowners who decide to remove deposits after lines are built.

Most of the crude oil and products pipeline companies re-route for deposits and move the line rather than pay very high damage expense.

Summary of Tabulations and Remarks
Questionnaire No. 7

Pipeline companies re-route lines around swamps, peat bogs, or other inaccessible areas only if it incurs no additional cost.

In areas, which are inaccessible due to lack of roads, it is not a general policy to build a work road. Access roads used in construction are sometimes maintained for necessary repairs or maintenance.

Summary of Tabulations and Remarks
Questionnaire No. 8

In open country, the policy of the majority of natural gas pipeline companies as to spacing between loop lines, is 6' to 25' for 12" and smaller size lines, and 12' to 50' for larger lines. With crude oil and products pipeline companies, the spacing ranges from 3' to 25' for 12" and smaller lines, and 6' to 25' for larger lines. One gas pipeline company reports that in open country, large size looped lines are laid closer than 20'; however, if blasting is necessary to cut the ditch, it is desirable to have as much as 200' clearance. On the other hand, an oil pipeline company reporting 5' usual spacing, increases this to 10' minimum where blasting rock is required. Another reports that the only requirement is to give sufficient room to provide maintenance.

At highway and railroad crossings, the policy is about the same as in open country.

At river crossings, most companies space multiple lines 30' to 300'. One oil pipeline company reporting 5' spacing in open country, maintains 25' minimum spacing in river beds, regaining the 5' spacing within a few hundred feet of the water's edge. Where rock would occasion blasting, spacing would be greater.

Through subdivided or populated areas, most natural gas companies use 6' to 25' spacing for lines under 22" in size, and 12' to 50' spacing for 22" and larger lines. Most crude oil and products pipeline companies report 3' to 5' for lines under 22", with none spaced over 25' regardless of size. Gas pipeline companies reduce the spacing in populated areas where Type B Construction, or better, is used. One gas pipeline company reports that, in populated areas, an effort is made to follow diverse routes, while another separates the lines at least one city block apart. An oil pipeline company reports that in some "pipe line alleys" the lines are as close together as 3', with spacing worked out with the company involved in the case of foreign lines.

TABULATION OF ANSWERS TO QUESTIONNAIRE NO. 7

1. In cases where the most direct pipeline location crosses sizeable swamps, peat bogs or other inaccessible areas, is it your company's general policy to:

	Yes	No
(a) Re-route the line around the area even though it is rather costly and results in a longer line?		
A. Natural Gas Pipelines	14	18
B. Crude Oil and Products Pipelines	4	8
C. Municipalities (Water and Sewer)	1	3
(b) Re-route the line around the area only if it incurs no additional cost due to more favorable construction conditions?		
A. Natural Gas Pipelines	21	7
B. Crude Oil and Products Pipelines	7	5
C. Municipalities (Water and Sewer)	3	-
(c) Install the line through the area since it is the most direct route?		
A. Natural Gas Pipelines	10	10
B. Crude Oil and Products Pipelines	4	6
C. Municipalities (Water and Sewer)	2	1

2. In cases where the pipeline is located in areas which are inaccessible due to lack of roads, does your company generally:

(a) Build and maintain a work road on the Right-of-Way (including culverts and/or bridges)?		
A. Natural Gas Pipelines	16	18
B. Crude Oil and Products Pipelines	1	11
C. Municipalities (Water and Sewer)	2	3
(b) Build and maintain a work road as above, but off the Right-of-Way?		
A. Natural Gas Pipelines	8	20
B. Crude Oil and Products Pipelines	1	11
C. Municipalities (Water and Sewer)	1	3

At terminal points such as stations, most gas pipeline companies use 6' to 10' spacing for the smaller lines, and 6' to 50' for 22" and larger lines. Oil pipeline companies use 3' to 5' spacing, and none space over 25' regardless of size.

At block valves, most gas pipeline companies use 6' to 10' spacing for 12" and smaller lines, and 12' to 50' for larger lines. Most oil pipeline companies use 3' to 25' spacing. For block valves in open country, the line spacing would not change.

Municipalities, with water mains, normally refer to spacing of loop connections as grid system interconnections which are spaced according to type

of water use and demand, density of population, and fire demand as necessary for adequate fire supply. One municipality reports grid interconnections for small size lines of 5000' in open country, 1600' to 2000' at highway and railroad crossings, 2000' at river crossings, and through subdivided or populated areas, 800' for 12" and smaller lines, 1600' for 12" to 22" lines. Another municipality reports the ultimate goal is to have no dead-end mains.

Sheet 1 of 2

TABULATION OF ANSWERS TO QUESTIONNAIRE NO. 8

What is the usual policy of your company as to spacing between Loop Lines in the following locations:

		3' - 5'	6' - 10'	12' - 25'	30' - 50'	50' - 300'
(1) In Open Country						
A. Natural Gas Pipelines	- 12" and smaller	-	12	11	6	-
	12" to 22"	-	3	15	10	-
	22" and larger	-	-	10	13	-
B. Crude Oil and Products	- 12" and smaller	3	4	3	1	-
	12" to 22"	1	4	4	1	-
	22" and larger	-	1	4	1	-
(2) At Highway and Railroad Crossings						
A. Natural Gas Pipelines	- 12" and smaller	1	6	15	5	1
	12" to 22"	-	2	12	9	1
	22" and larger	-	-	9	13	1
B. Crude Oil and Products	- 12" and smaller	6	2	2	1	-
	12" to 22"	4	3	2	1	-
	22" and larger	2	-	3	1	-
(3) At River Crossings						
A. Natural Gas Pipelines	- 12" and smaller	-	5	3	10	8
	12" to 22"	-	3	2	11	7
	22" and larger	-	-	3	7	9
B. Crude Oil and Products	- 12" and smaller	1	-	-	5	2
	12" to 22"	1	-	-	2	4
	22" and larger	-	-	-	2	3
(4) Through Subdivided or Populated Areas						
A. Natural Gas Pipelines	- 12" and smaller	3	10	8	2	-
	12" to 22"	1	7	9	5	-
	22" and larger	-	3	10	6	-
B. Crude Oil and Products	- 12" and smaller	6	3	2	-	-
	12" to 22"	5	2	2	-	-
	22" and larger	2	2	2	-	-

TABULATION OF ANSWERS TO QUESTIONNAIRE NO. 8 (cont'd)

		3' - 5'	6' - 10'	12' - 25'	30' - 50'	50' - 300'
(5) At Terminal Points Such as Stations						
A. Natural Gas Pipelines	12" and smaller	4	9	4	4	-
	12" to 22"	1	8	6	5	-
	22" and larger	-	4	6	6	-
B. Crude Oil and Products	12" and smaller	6	3	2	-	-
	12" to 22"	5	3	2	-	-
	22" and larger	3	1	2	-	-
(6) At Block Valves						
A. Natural Gas Pipelines	12" and smaller	2	14	7	5	-
	12" to 22"	1	6	11	9	-
	22" and larger	1	2	10	9	-
B. Crude Oil and Products	12" and smaller	4	4	3	-	-
	12" to 22"	4	3	3	-	-
	22" and larger	3	1	2	-	-

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Flow Equations for Natural Gas Pipelines, by R. F. Bukacek. (Proc. Paper 1667, June, 1958. Prior discussion: 1691; 1920. Discussion closed.)
by R. F. Bukacek (closure) 65

Note: Paper 2041 is part of the copyrighted Journal of the Pipeline Division, Proceedings of the American Society of Civil Engineers, Vol. 85, PL 2, May, 1959.

FLOW EQUATIONS FOR NATURAL GAS PIPELINES[a]

Closure by R. F. Bukacek

R. F. BUKACEK.[1]—The question of the transition region raised by Mr. Schomaker is one which admits of several points of view. Examination of the Bureau of Mines* results indicates the following: (1) There is no single behavior pattern in the transition range. The curves in the report which show a particular transition behavior for all pipe sizes were arbitrarily drawn. (2) The only consistant feature of the different data sets covering the transition region is the fact that deviations from the limiting curves; (the curve for fully developed turbulent flow in smooth pipes, and the respective curves for flow in rough pipes) are almost as small as the experimental errors involved. The writer's position in the matter is that for commercial large-diameter pipes the transition behavior is probably unique for each pipe section and the assumption that rough pipe behavior is followed back to the junction with the smooth pipe law is probably as accurate as any. Considerably more experimental work in the transition region would be necessary to justify any other position.

a. Proc. Paper 1667, June, 1958, by R. F. Bukacek.

1. Instructor, Chem. Eng. Dept., Illinois Inst. of Technology, Chicago, Ill.

* Smith, R.V., Miller, J.S. and Ferguson, J.W., Flow of Natural Gas through Experimental Pipelines and Transmission Lines, Bureau of Mines Monograph No. 9 (1956).

PROCEEDINGS PAPERS

The technical papers published in the past year are identified by number below. Technical-division sponsorship is indicated by an abbreviation at the end of each Paper Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Pipeline (PL), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways and Harbors (WW), divisions. Papers sponsored by the Department of Conditions of Practice are identified by the symbols (PP). For titles and order coupons, refer to the appropriate issue of "Civil Engineering." Beginning with Volume 82 (January 1956) papers were published in Journals of the various Technical Divisions. To locate papers in the Journals, the symbols after the paper number are followed by a numeral designating the issue of a particular Journal in which the paper appeared. For example, Paper 1859 is identified as 1859 (HY 7) which indicates that the paper is contained in the seventh issue of the Journal of the Hydraulics Division during 1958.

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MAY: 1621(HW2), 1622(HW2), 1623(HW2), 1624(HW2), 1625(HW2), 1626(HW2), 1627(HW2), 1628(HW2), 1629 (ST3), 1630(ST3), 1631(ST3), 1632(ST3), 1633(ST3), 1634(ST3), 1635(ST3), 1636(ST3). 1637(ST3), 1638(ST3), 1639(WW3), 1640(WW3), 1641(WW3), 1642(WW3), 1643(WW3), 1644(WW3), 1645(SM2), 1646(SM2), 1647 (SM2), 1648(SM2), 1649(SM2), 1650(SM2), 1651(HW2), 1652(HW2)[c], 1653(WW3)[c], 1654(SM2), 1655(SM2), 1656(ST3)[c], 1657(SM2)[c].

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AUGUST: 1725(HY4), 1726(HY4), 1727(SM3), 1728(SM3), 1729(SM3), 1730(SM3), 1731(SM3), 1732(SM3), 1733 (PO4), 1734(PO4), 1735(PO4), 1736(PO4), 1737(PO4), 1738(PO4), 1739(PO4), 1740(PO4), 1741(PO4), 1742 (PO4), 1743(PO4), 1744(PO4), 1745(PO4), 1746(PO4), 1747(PO4), 1748(PO4), 1749(PO4).

SEPTEMBER: 1750(IR3), 1751(IR3), 1752(IR3), 1753(IR3), 1754(IR3), 1755(ST5), 1756(ST5), 1757(ST5), 1758(ST5), 1759(ST5), 1760(ST5), 1761(ST5), 1762(ST5), 1763(ST5), 1764(ST5), 1765(WW4), 1766(WW4), 1767(WW4), 1768(WW4), 1769(WW4), 1770(WW4), 1771(WW4), 1772(WW4), 1773(WW4), 1774(IR3), 1775 (IR3), 1776(SA5), 1777(SA5), 1778(SA5), 1779(SA5), 1780(SA5), 1781(WW4), 1782(SA5), 1783(SA5), 1784 (IR3)[c], 1785(WW4)[c], 1786(SA5)[c], 1787(ST5)[c], 1788(IR3), 1789(WW4).

OCTOBER: 1790(EM4), 1791(EM4), 1792(EM4), 1793(EM4), 1794(EM4), 1795(HW3), 1796(HW3), 1797(HW3), 1798(HW3), 1799(HW3), 1800(HW3), 1801(HW3), 1802(HW3), 1803(HW3), 1804(HW3), 1805(HW3), 1806 (HY5), 1807(HY5), 1808(HY5), 1809(HY5), 1810(HY5), 1811(HY5), 1812(SM4), 1813(SM4), 1814(ST6), 1815 (ST6), 1816(ST6), 1817(ST6), 1818(ST6), 1819(ST6), 1820(ST6), 1821(ST6), 1822(EM4), 1823(PO5), 1824 (SM4), 1825(SM4), 1826(SM4), 1827(ST6)[c], 1828(SM4)[c], 1829(HW3)[c], 1830(PO5)[c], 1831(EM4)[c], 1832(HY5)[c]

NOVEMBER: 1833(HY6), 1834(HY6), 1835(SA6), 1836(ST7), 1837(ST7), 1838(ST7), 1839(ST7), 1840(ST7), 1841(ST7), 1842(SU3), 1843(SU3), 1844(SU3), 1845(SU3), 1846(SU3), 1847(SA6), 1848(SA6), 1849(SA6), 1850(SA6), 1851(SA6), 1852(SA6), 1853(SA6), 1854(ST7), 1855(SA6)[c], 1856(HY6)[c], 1857(ST7)[c], 1858 (SU3)[c].

DECEMBER: 1859(HY7), 1860(IR4), 1861(IR4), 1862(IR4), 1863(SM5), 1864(SM5), 1865(ST8), 1866(ST8), 1867 (ST8), 1868(PP1), 1869(PP1), 1870(PP1), 1871(PP1), 1872(PP1), 1873(WW5), 1874(WW5), 1875(WW5), 1876 (WW5), 1877(CP2), 1878(ST8), 1879(ST8), 1880(HY7)[c], 1881(SM5)[c], 1882(ST8)[c], 1883(PP1)[c], 1884(WW5)[c], 1885(CP2)[c], 1886(PO6), 1887(PO6), 1888(PO6), 1889(PO6), 1890(HY7), 1891(PP1).

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JANUARY: 1892(AT1), 1893(AT1), 1894(EM1), 1895(EM1), 1896(EM1), 1897(EM1), 1898(EM1), 1899(HW1), 1900(HW1), 1901(HY1), 1902(HY1), 1903(HY1), 1904(HY1), 1905(PL1), 1906(PL1), 1907(PL1), 1908(PL1), 1909(ST1), 1910(ST1), 1911(ST1), 1912(ST1), 1913(ST1), 1914(ST1), 1915(ST1), 1916(AT1)[c], 1917(EM1)[c], 1918(HW1)[c], 1919(HY1)[c], 1920(PL1)[c], 1921(SA1)[c], 1922(ST1)[c], 1923(EM1), 1924(HW1), 1925(HW1), 1926 (PL1), 1927(HW1), 1928(HW1), 1929(SA1), 1930(SA1), 1931(SA1), 1932(SA1).

FEBRUARY: 1933(HY2), 1934(HY2), 1935(HY2), 1936(SM1), 1937(SM1), 1938(ST2), 1939(ST2), 1940(ST2), 1941(ST2), 1942(ST2), 1943(ST2), 1944(ST2), 1945(HY2), 1946(PO1), 1947(PO1), 1948(PO1), 1949(PO1), 1950(HY2)[c], 1951(SM1)[c], 1952(ST2)[c], 1953(PO1)[c], 1954(CO1), 1955(CO1), 1956(CO1), 1957(CO1), 1958 (CO1), 1959(CO1).

MARCH: 1960(HY3), 1961(HY3), 1962(HY3), 1963(IR1), 1964(IR1), 1965(IR1), 1966(IR1), 1967(SA2), 1968 (SA2), 1969(ST3), 1970(ST3), 1971(ST3), 1972(ST3), 1973(ST3), 1974(ST3), 1975(ST3), 1976(WW1), 1977 (WW1), 1978(WW1), 1979(WW1), 1980(WW1), 1981(WW1), 1982(WW1), 1983(WW1), 1984(SA2), 1985(SA2)[c], 1986(IR1)[c], 1987(WW1)[c], 1988(ST3)[c], 1989(HY3)[c].

APRIL: 1990(EM2), 1991(EM2), 1992(EM2), 1993(HW2), 1994(HY4), 1995(HY4), 1996(HY4), 1997(HY4), 1998 (SM2), 1999(SM2), 2000(SM2), 2001(SM2), 2002(ST4), 2003(ST4), 2004(ST4), 2005(ST4), 2006(PO2), 2007 (HW2)[c], 2008(EM2)[c], 2009(ST4)[c], 2010(SM2)[c], 2011(SM2)[c], 2012(HY4)[c], 2013(PO2)[c].

MAY: 2014(AT2), 2015(AT2), 2016(AT2), 2017(HY5), 2018(HY5), 2019(HY5), 2020(HY5), 2021(HY5), 2022 (HY5), 2023(PL2), 2024(PL2), 2025(PL2), 2026(PP1), 2027(PP1), 2028(PP1), 2029(PP1), 2030(SA3), 2031(SA3), 2032(SA3), 2033(SA3), 2034(ST5), 2035(ST5), 2036(ST5), 2037(ST5), 2038(PL2), 2039(PL2), 2040(AT2)[c], 2041(PL2)[c], 2042(PP1)[c], 2043(ST5)[c], 2044(SA3)[c], 2045(HY5)[c], 2046(PP1), 2047(PP1).

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c. Discussion of several papers, grouped by divisions.

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NO. PL 2
PART 2

Your attention is invited

NEWS OF THE PIPELINE DIVISION OF ASCE

JOURNAL OF THE PIPELINE DIVISION
PROCEEDINGS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

DIVISION ACTIVITIES
PIPELINE DIVISION

Proceedings of the American Society of Civil Engineers

NEWS

May, 1959

CLEVELAND MEETING

The ASCE convention in Cleveland, Ohio, May 4-8, included two joint sessions of the Pipeline and Power divisions on the coal slurry pipeline and the coal-drying plant. The papers included: "The Coal Pipeline" by V. D. Hanson, Chief Metallurgical Engineer, Consolidated Coal Co., Pittsburgh; "Pumping Solids Through Pipelines" by Julian Nardi, Ford, Bacon & Davis, Inc., New York; "Civil Engineering Features of the Eastlake Station" by L. A. Olson, Cleveland Electric Illuminating Co., "Coal Pipeline Construction" by David R. Williams, Williams Bros., Tulsa; "Design and Operation of Drying Plant" by C. A. Dauber, Cleveland Electric Illuminating Co.; "Installation of 138KV Pipe-Type Cable in Cleveland" by J. J. Pokorny, Cleveland Electric Illuminating Co. A field trip provided inspection of a pumping station along the route of the pipeline and a tour of the Eastlake power plant and coal-drying plant.

The final technical session included papers on "Thermal Electric Pipeline Supplies Hi-Vis Fuel to New Generating Station" by A. C. Purdue, Fluid Systems Inc., New Haven, Conn.; "Electronic Pressure Control for Pipeline Pumping Stations" by W. M. Sorenson, Sohio Pipeline Co., St. Louis; and a construction movie by Columbia Gas System of its 262-mile "Toughest Inch" pipeline.

COMMITTEE MEETINGS AT CLEVELAND

Actions taken at the technical and executive committee meetings held at Cleveland in connection with the convention cannot be included in this issue since this "News" must be prepared a month and a half ahead of publication date.

The Executive Committee scheduled an open meeting with all Pipeline Division members in attendance. Also, the three new committees on Pipeline Planning, Pipeline Installation, and Pipeline Operation & Maintenance were organized with task groups as suggested by the various members.

A Task Group under the new Committee on Pipeline Installation was

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initiated to make an intensive study of flotation of large size lines and the correct weighting in marshy areas. It is a matter of judgement to design concrete coating for proper weighting of lines—the present basis for design of natural gas river crossing lines, with the selection of the appropriate specific gravity of the soils and backfills, seems to be satisfactory but apparently is not applicable in designing for swamps where depth of cover is utilized. The over-design of concrete coating for a few thousand feet of river crossing lines is on the side of safety and the extra costs are a small percentage of the job. However, the addition of concrete coating for many miles of swamp can result in excessive costs. Although an effort is made to determine the shear strength of soils and sediments, the holding power of the backfill is not predictable. One oil company advised that pipelines transporting heavy oils may be subject to flotation when the operation is changed to transporting products or lighter liquids.

COMMITTEE ON PIPELINE CROSSINGS OF RAILROADS AND HIGHWAYS

A committee meeting was held in St. Louis, February 25, 26 and 27, for the purpose of completing the final draft of the proposed specifications for submission to the various organizations for their approval, at least with respect to the highway interests. After these approvals, the specification will be submitted to the A.S.A. B 31 Subcommittee 8 for adoption as a standard.

A Steering Committee to administer a proposed research program was organized at the St. Louis meeting on February 26. This research program was proposed by James C. Fisher, Chairman of the Task Group on Loads, Stresses and Design Equations. The program will be conducted as financial assistance is obtained from industry on a prorated basis amongst the various interested organizations.

The main purpose of the proposed research program is twofold. First, it is proposed to conduct a field study, covering at least a five-year period, of the long-time structural performance of dummy casing pipe installations crossing under railroads and highways providing a wide variation in soil and climatic conditions, particularly with respect to the determination of the deflection of casing pipes in service and the study of the longitudinal sag characteristics of the casing pipe. Secondly, it is proposed to conduct a laboratory investigation, covering a two-year period, directed towards the determination of the qualitative values of the modulus of passive resistance for several general types of soils under various conditions.

The committee has worked diligently for the past two years in writing the proposed specification for pipeline crossings. The design portion is based on the so-called "Iowa formula" as developed by Dr. M. G. Spangler, Research Professor of Civil Engineering, Iowa State College, Ames, Iowa, who is a well-known authority in the highway and pipeline industries. Certain values, considered conservative by the majority of the committee, have been recommended for use in the design portion. Dissensions have been submitted against these values by members of the Committee contending little or no factual information is available to substantiate these recommended values. The need for this factual information has existed for some time. If the results of this proposed research program prove that the majority of the

Committee is correct in assuming these values as conservative, this will substantiate the proposed specification in addition to providing the engineering profession and industry with valuable factual information.

Dr. M. G. Spangler was appointed Program Director for the proposed research program. The Steering Committee is comprised of the following representatives from various organizations:

Chairman	J. E. Thompson	A.S.C.E.
Vice Chairman	J. C. Fisher	A.S.C.E.
	Harold Allen	U.S.B.P.R.
	L. L. Elder	A.G.A. Transmission and A.G.A. Research Committee
	G. D. Mock	A.S.A.
	C. Neufeld	A.R.E.A. Committee #15
	E. A. Slade	A.P.I.
	Rockwell Smith	A.A.R.
	E. R. Trunk	A.G.A. Distribution
	A. J. Wegmann	A.R.E.A. Committee #1
	A. B. Wilder	Manufacturers Representative

In February, the Committee on Division Activities approved a new committee within the Highway Division on pipeline crossings with the purpose: "to study from the highway viewpoint the problems of location, design, construction, maintenance, repair, replacement and relocation of pipelines (other than highway facilities) crossing under and over highways; to cooperate with committees of like purpose within other technical divisions in the development of policy, specifications, standards or manuals of practice for such crossings." Members of this new Highway Division committee, who are now serving as members of the Pipeline Division committee, are tentatively H. H. Brown, E. F. Kauffman, S. E. Ridge, and R. R. Rowe. Since this new committee has a similar objective to that of the Pipeline Division, the Committee on Division Activities suggests that every effort be made to assure cooperation between the committee of the Highway Division and the committee which has been in operation for several years within the Pipeline Division.

LOS ANGELES PIPELINE TECHNICAL GROUP

A Pipeline Technical Group of the Los Angeles Section is being organized by Herbert J. Chapton, Projects Design Engineer, Los Angeles Water System, 800 Patterson Avenue, Glendale 2, California. Letters inviting participation in this Technical Group were mailed out by him to all types of engineers who are engaged in pipeline work in this area. If you are interested in this activity, get in touch with Herb Chapton.

PIPELINE LOCATION

A report on the existing policies relative to Pipeline Location has been completed by Chairman Howard M. Hayes. This report resulted from questionnaires mailed out to about 100 natural gas, crude oil, and products pipeline companies and municipalities. By publication in the Journal, widespread discussions should be obtained. Chairman Hayes will further explore

these policies by queries to pipeline rights-of-way groups and pipeline contractors.

The Task Committee on Pipeline Location, with the purpose of writing a manual, had a successful meeting in New Orleans in February improving outlines and assigning writing tasks on surveys and related functions. Those in attendance: Chairman E. O. Scott of Service Pipeline Co., Tulsa; E. H. Schmidt of E. H. Schmidt & Associates, Tulsa; J. C. Faulkner of Texas Eastern Transmission Corp., Shreveport; John F. Schaffer of El Paso Natural Gas Co., El Paso; and R. H. Dodds of Gibbs & Hill, Inc., New York. Professor Milton O. Schmidt and R. H. Dodds were specially appointed to represent the Surveying & Mapping Division in this Task Committee.

COORDINATING COMMITTEE ON TRANSPORTATION

One of the important actions taken in February by the Board of Direction was the creation of a Coordinating Committee on Transportation to report directly to the Committee on Division Activities with this stated purpose: (a) encourage more exchange and contact among the several Technical Divisions interested in transportation, (b) act as a focal point for initiating studies and disseminating information on broad transportation policies, (c) make a detailed study of existing Technical Division activities and recommend changes to fill voids and eliminate overlap, and (d) study contacts with organizations interested in broad transportation policies but not directly connected with the Society.

Personnel for this committee will be appointed by the Committee on Division Activities to serve until October 1960. In addition to a member representing our Pipeline Division, one member from each of the following Divisions will serve: Air Transport, City Planning, Highway, Waterways and Harbors, and a representative of the railroad industry. In addition, one member of the Committee on Division Activities will be selected to serve as Chairman.

PERSONALS

Joe E. Thompson, member of the Executive Committee and Chairman of the Committee on Pipeline Crossings of Railroads and Highways, was promoted to Assistant Chief Engineer of Natural Gas Pipeline Company of America, Chicago. He was formerly Superintendent of Pipeline Construction.

William B. Poor, of the Advisory Committee, was elected by Ford, Bacon & Davis, Inc., as Senior Vice President.

Duane P. Smith of the Advisory Committee, has been transferred by Bechtel Corporation from San Francisco to Paris, France.

M. J. Shelton, Chairman of the Task Group on Compilation of a Bibliography of Reference Materials, is Chief Engineer of Koebig and Koebig, Consultants, at San Diego, California. He was formerly Deputy Director of the California Department of Water Resources.

Ralph C. Hughes, Jr. of the Committee on Pipeline Operation & Maintenance is now with Cosden Pipe Line Co. at Big Spring, Texas. He was formerly with Pipe Line Technologists, Houston.

ACTIONS OF THE A.S.A. SECTIONAL COMMITTEE B31

The actions of the ASA Sectional Committee B31—Sponsor ASME—are a result of requests to the Secretary, 420 Lexington Avenue, New York 17, N.Y., from individuals or companies for interpretation of a particular section of the Code for Pressure Piping ASA B31.1-1955, or changes suggested by practical experience in using the Code. The subcommittee involved submits the information or change to the B31 executive committee for approval as a "Case." Upon approval, the Case is published in the ASME "Mechanical Engineering" and in the ASA "Magazine of Standards."

Actions in Cases Nos. 24 through 34 have been summarized in previous issues of this "News." For your information, the following Cases appeared in the March 1959 "Mechanical Engineering" with extensive tables and other data, all of which are under Section 1 of the Code:

Case No. 26 (reopened)—piping for aqueous type reactors in nuclear energy installation—modifications and changes in wording. Case No. 34 (reopened)—austenic steel pipe—change in wording and table of stress values.

Case No. 35—the specification of fire box quality pipe to ASTM Specification A-155 in Table 2A. Case No. 37—changes in paragraph 122. Case No. 38—piping components made of Nodular Cast Iron under Sections 1, 2 and 3 pending completion of studies in progress in Sectional Committees B16 and B31. Case No. 39—use of type 304 stainless steel in nuclear energy installation. Case No. 40—references to reinforced concrete pipe specifications for service water and condensing water systems.

YOUR NEWSLETTER

This Newsletter is mailed out with the Journal which goes only to those members of the Society who have requested affiliation with the Pipeline Division as one of their two fields of professional interest. Members should use the coupon which appears monthly in Civil Engineering for affiliation.

Members of the Pipeline Division are invited to send to the Newsletter Editor any contributions or suggestions.

J B. Spangler, Newsletter Editor
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